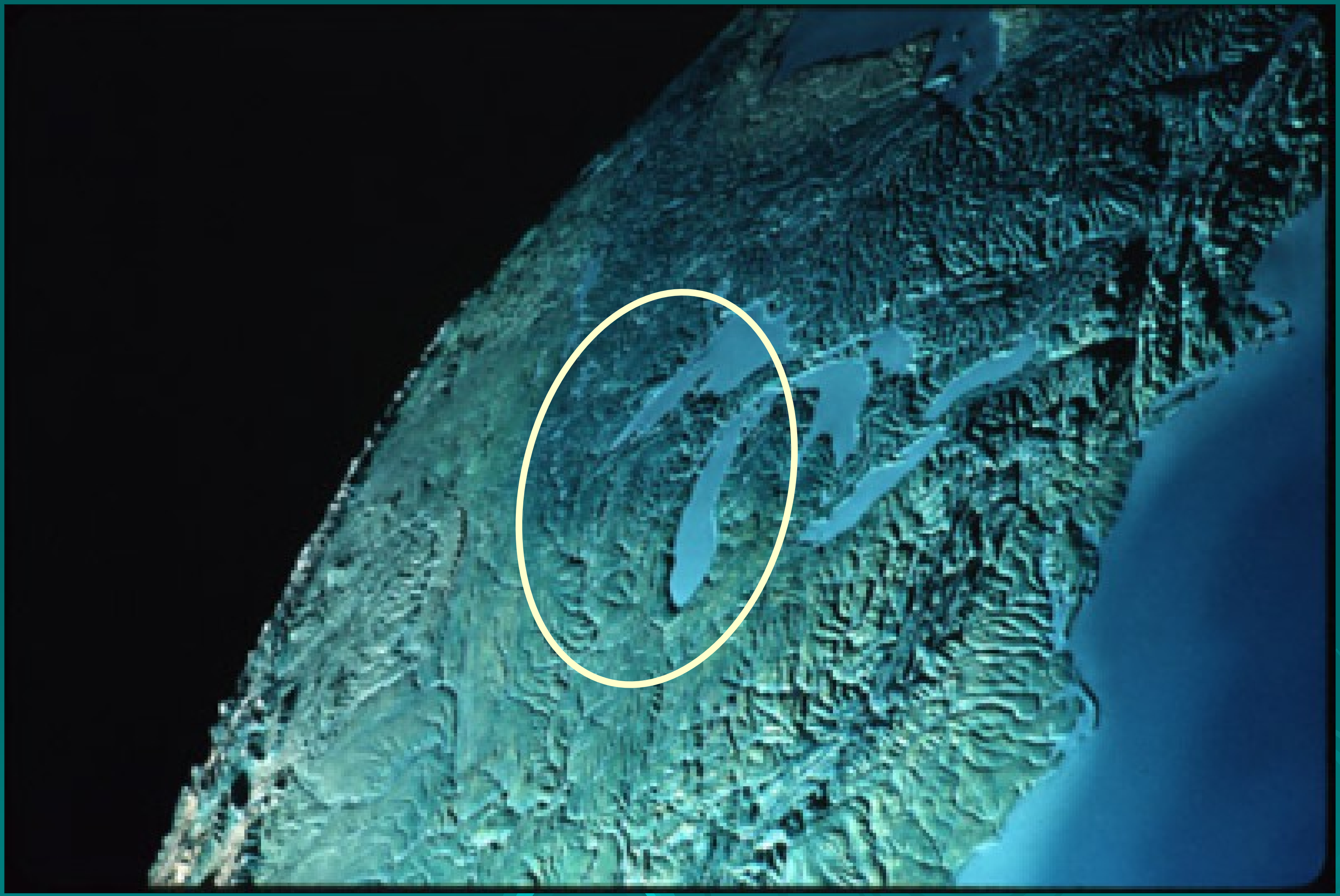
An Aquatic Synthesis for Great Lakes National Parks:

Using past efforts to guide
future research and monitoring

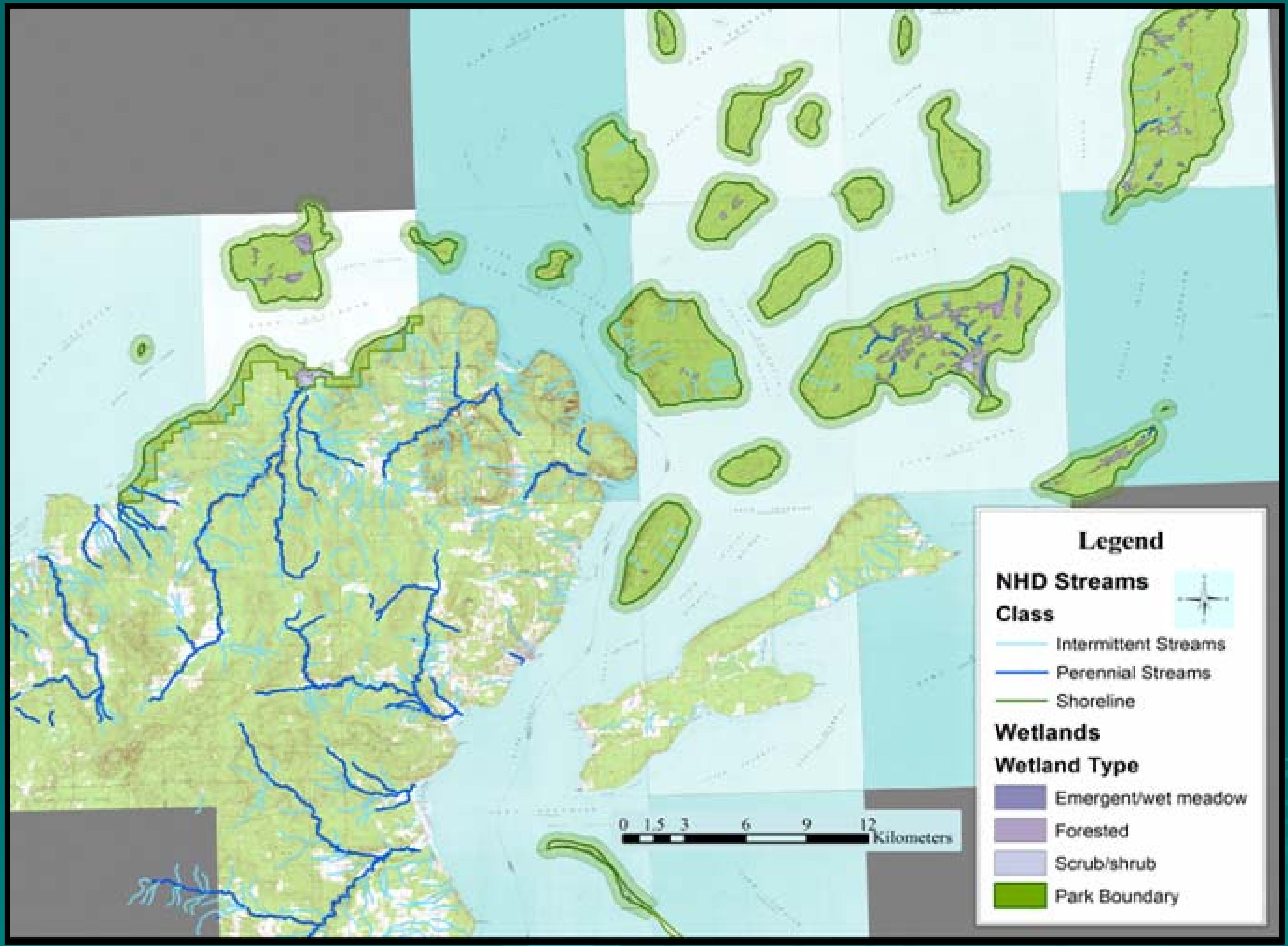
Brenda Moraska Lafrancois, NPS Midwest Region
Jay Glase, NPS Midwest Region

Great Lakes Regional Context

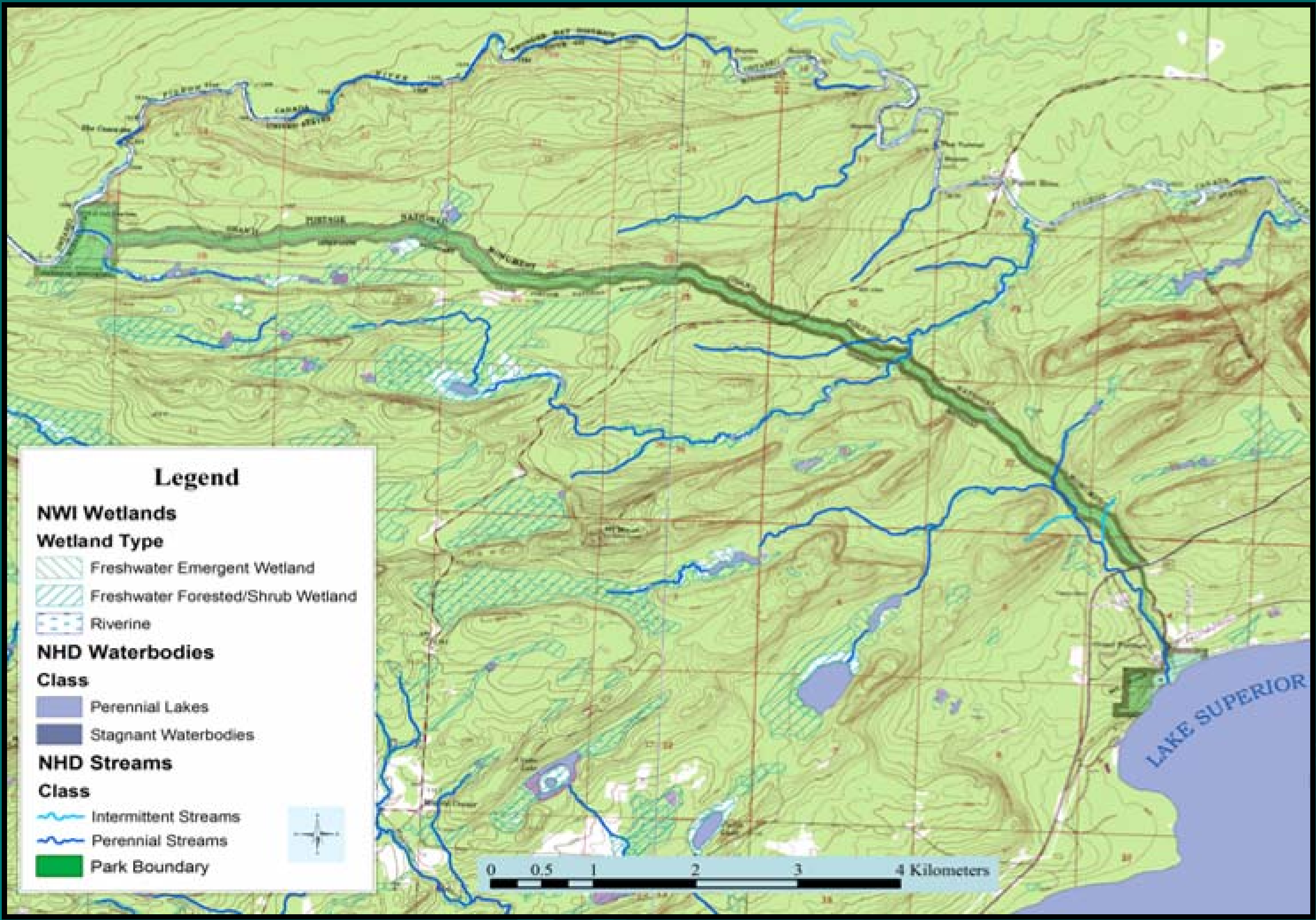


9 Great Lakes Network Parks

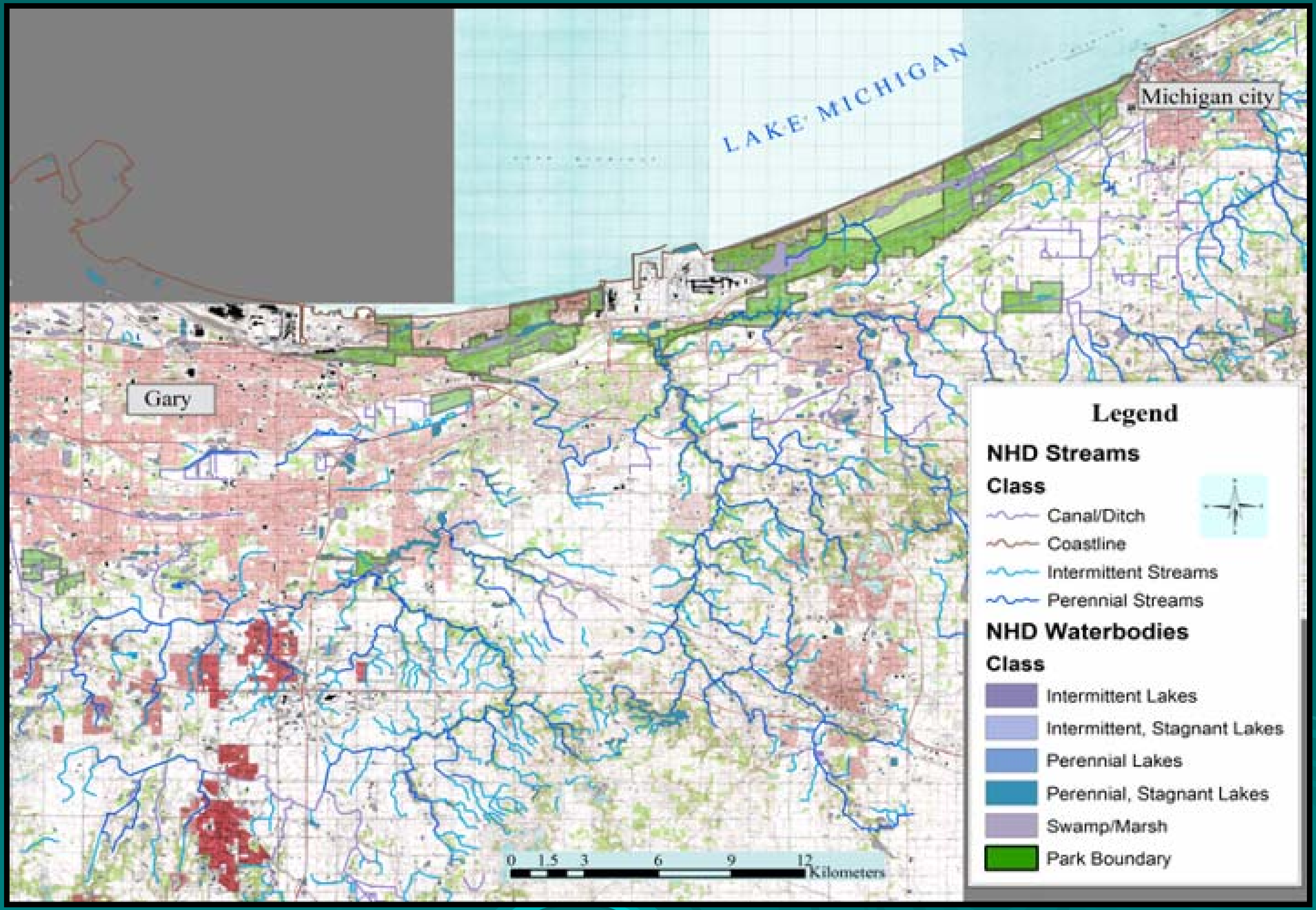
Apostle Islands NL



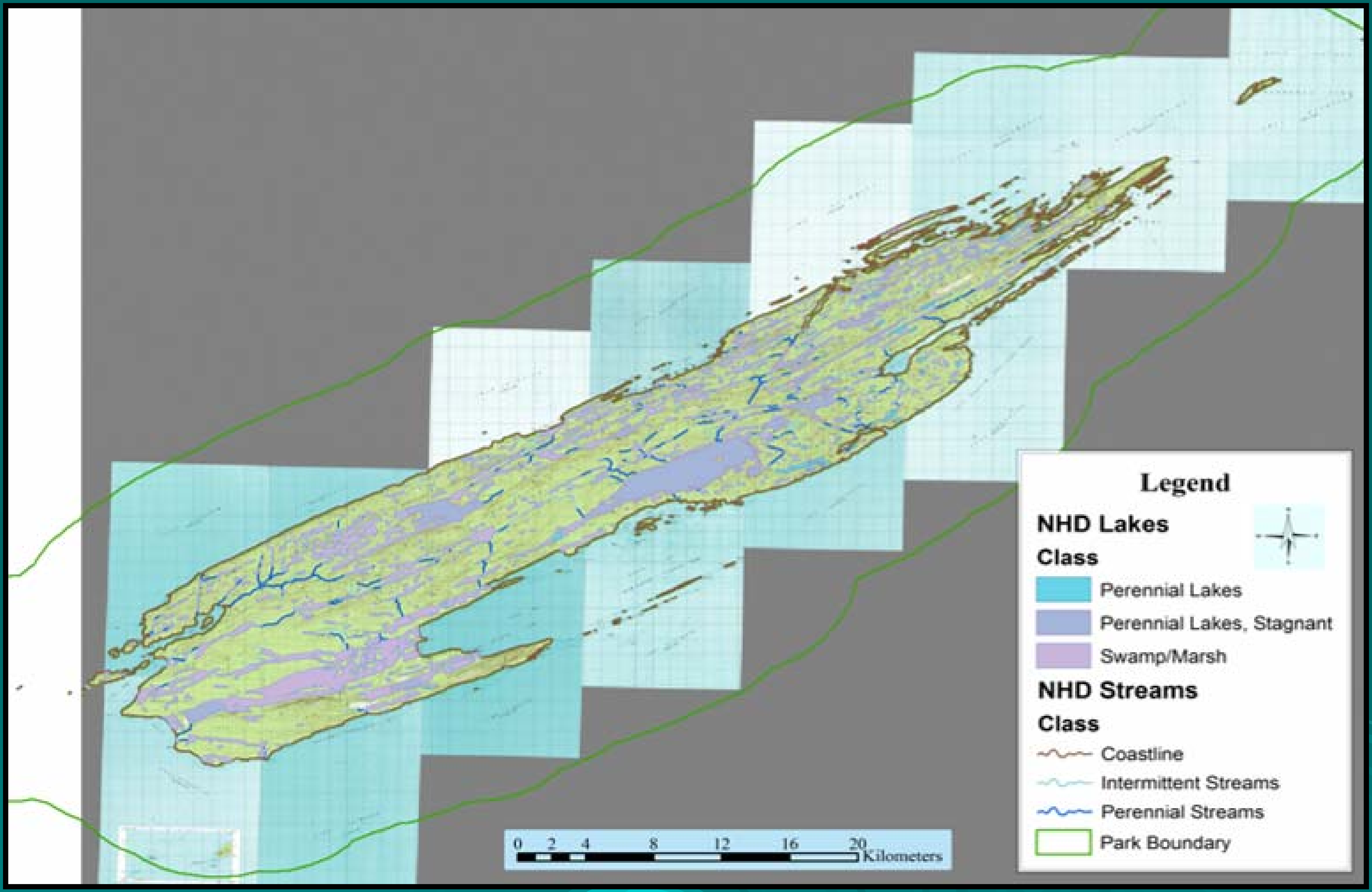
Grand Portage NM



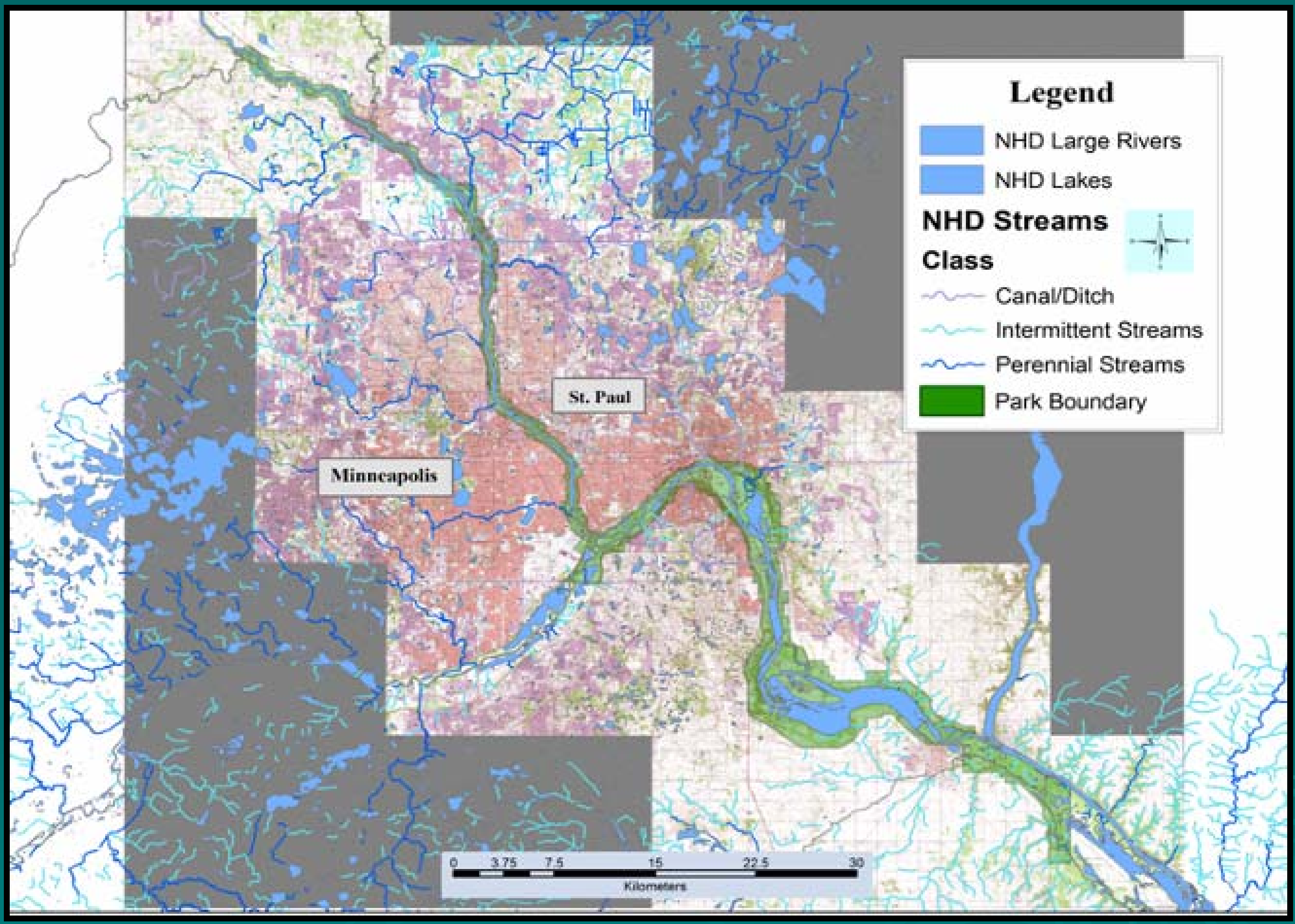
Indiana Dunes NL



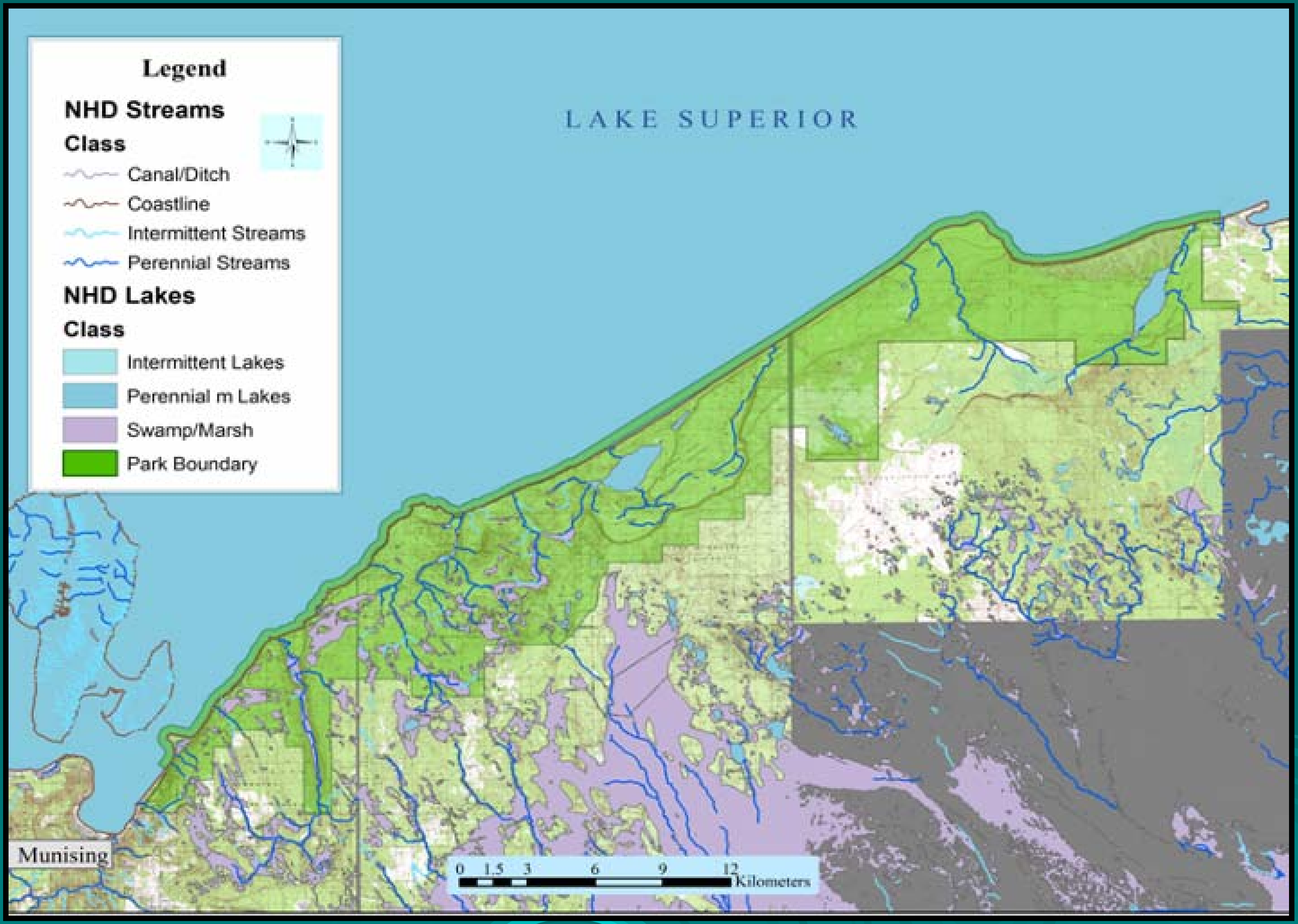
Isle Royale NP



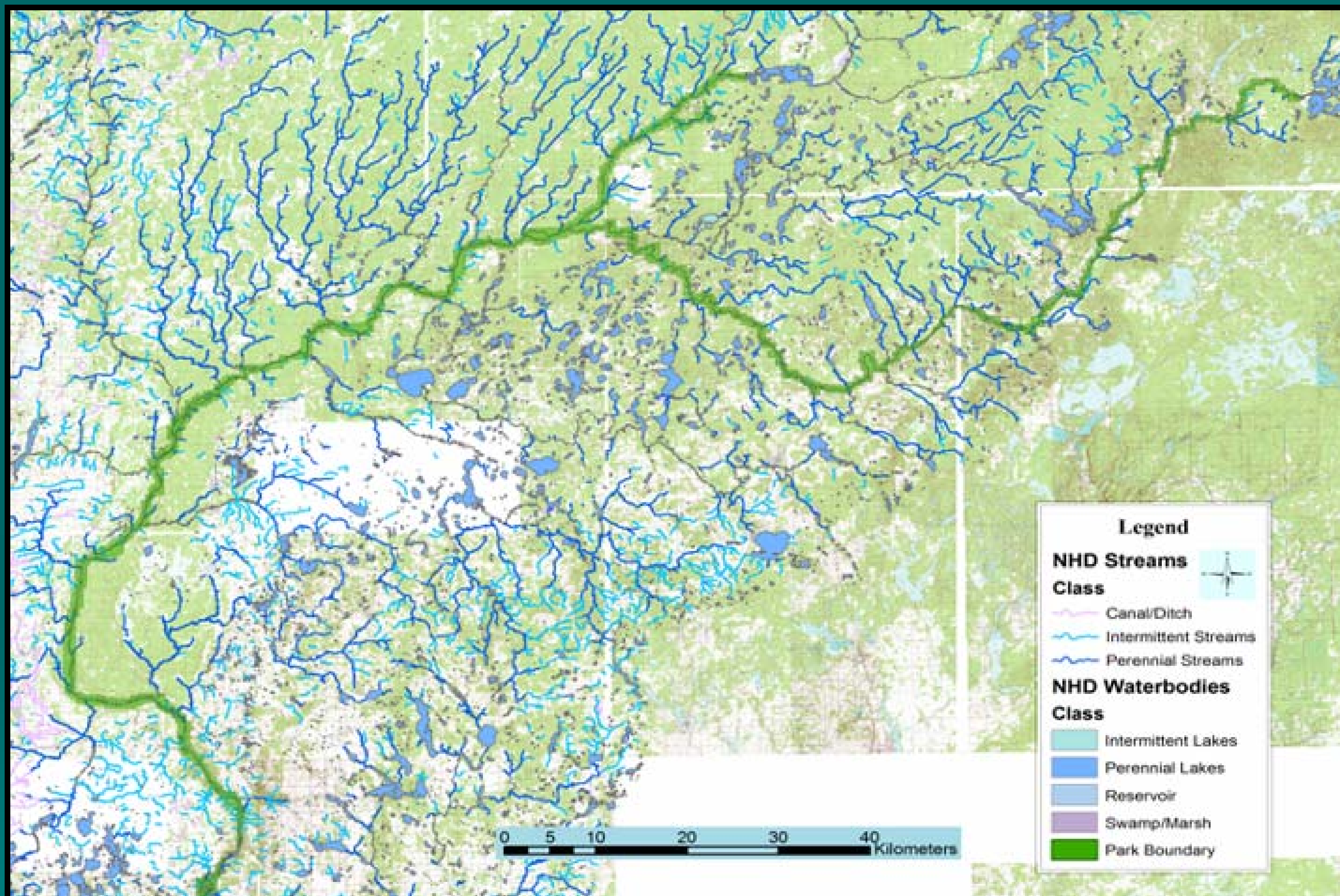
Mississippi NRRA



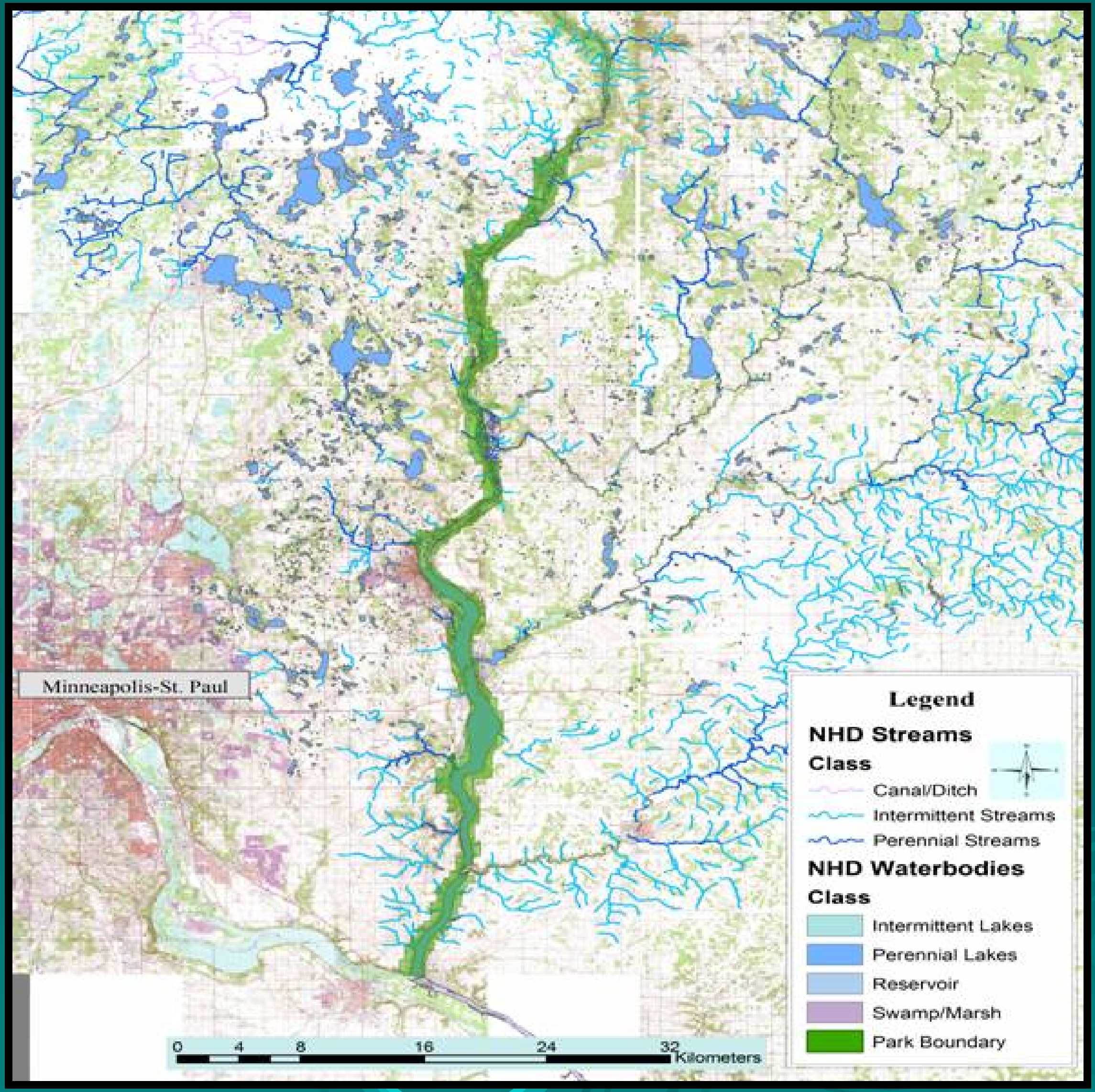
Pictured Rocks NL



St. Croix NSR

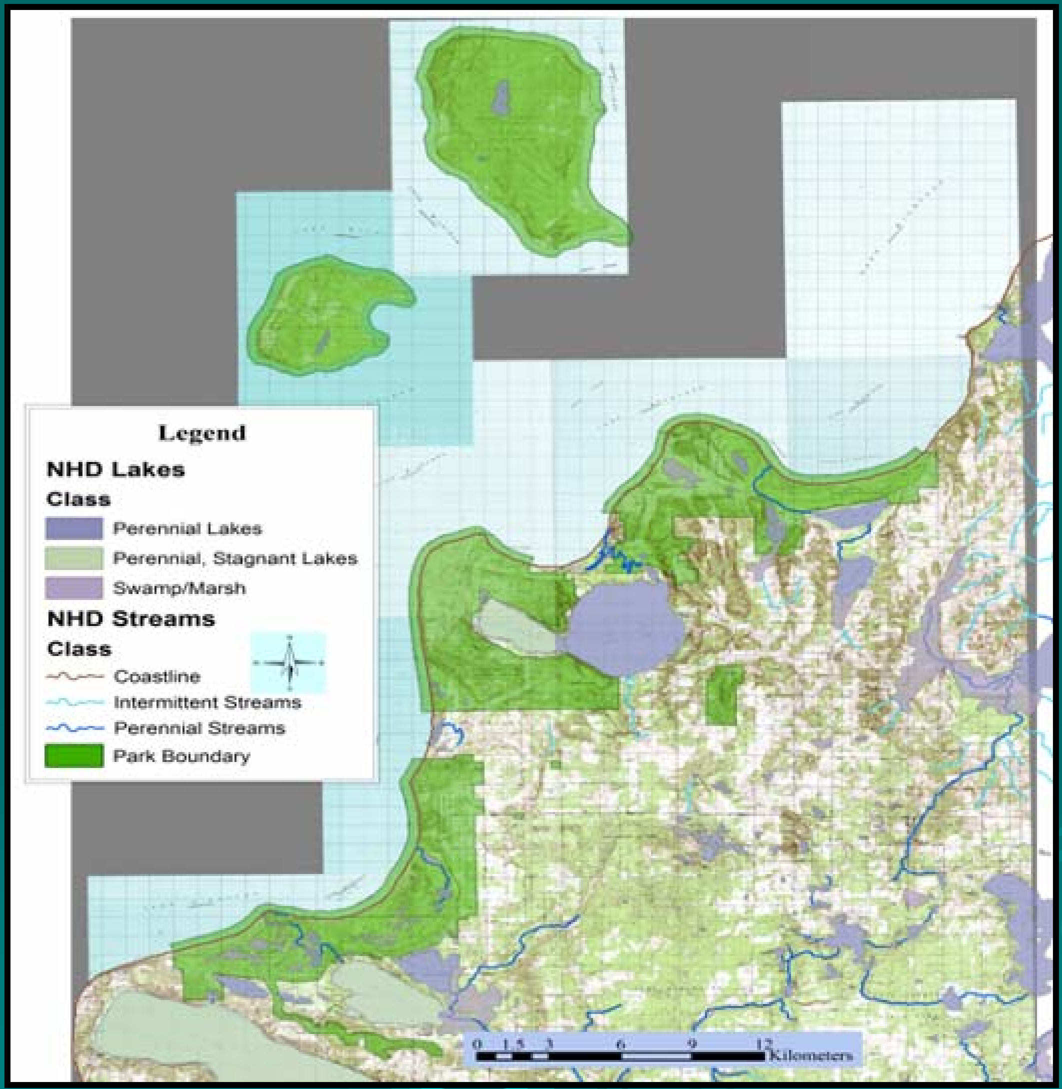

Legend
NHD Streams
Class
Canal/Ditch
Intermittent Streams
Perennial Streams
NHD Waterbodies
Class
Intermittent Lakes
Perennial Lakes
Reservoir
Swamp/Marsh
Park Boundary
0 5 10 20 30 40 Kilometers

St. Croix NSR

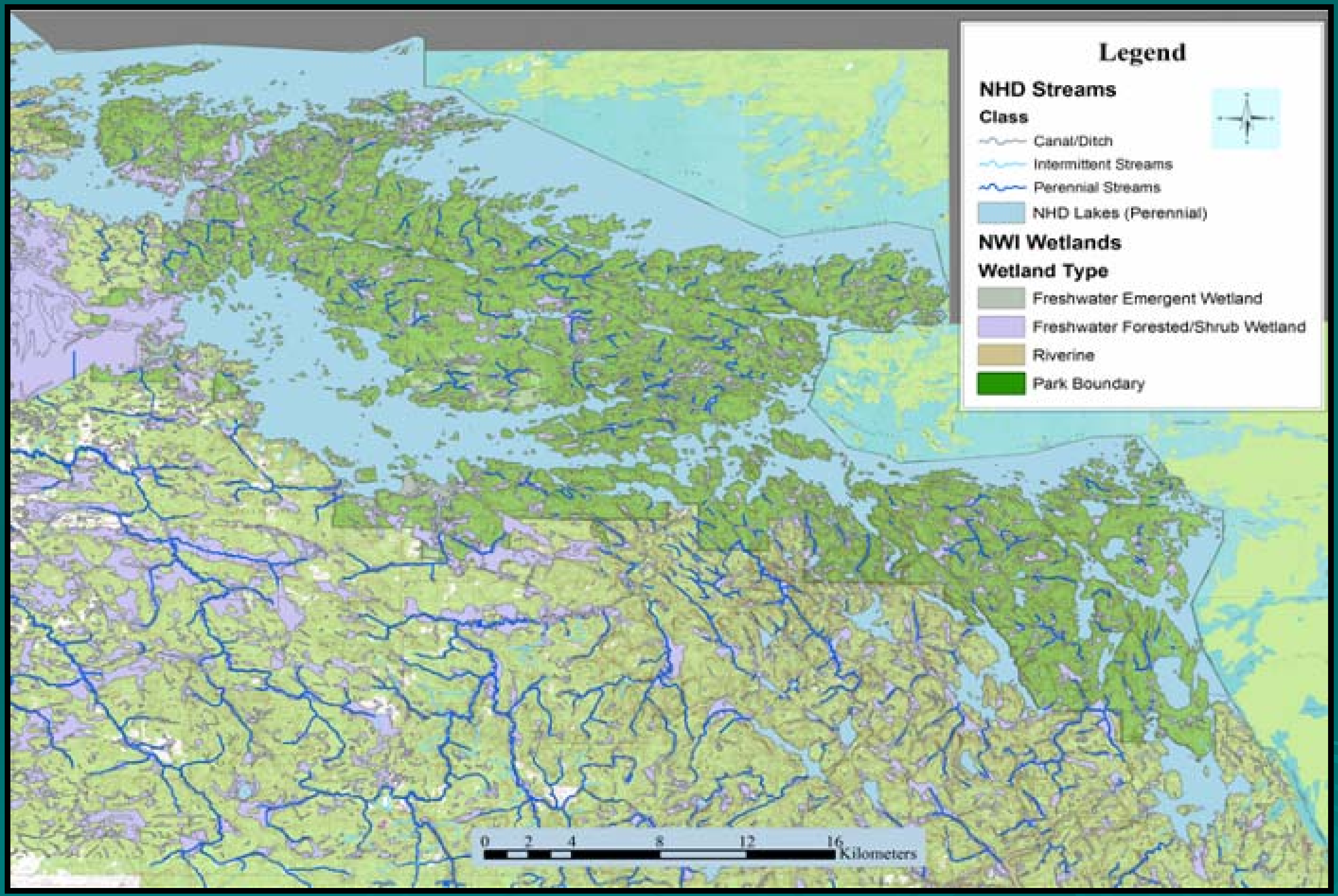


Minneapolis-St. Paul
Legend
NHD Streams
Class
Canal/Ditch
Intermittent Streams
Perennial Streams
NHD Waterbodies
Class
Intermittent Lakes
Perennial Lakes
Reservoir
Swamp/Marsh
Park Boundary
0 4 8 16 24 32 Kilometers

Sleeping Bear Dunes NL



Voyageurs NP



Open Waters

Nearshore Waters

Coastal Wetlands

Coastal Lagoons

Inland Wetlands

Aquatic Bed

Marsh

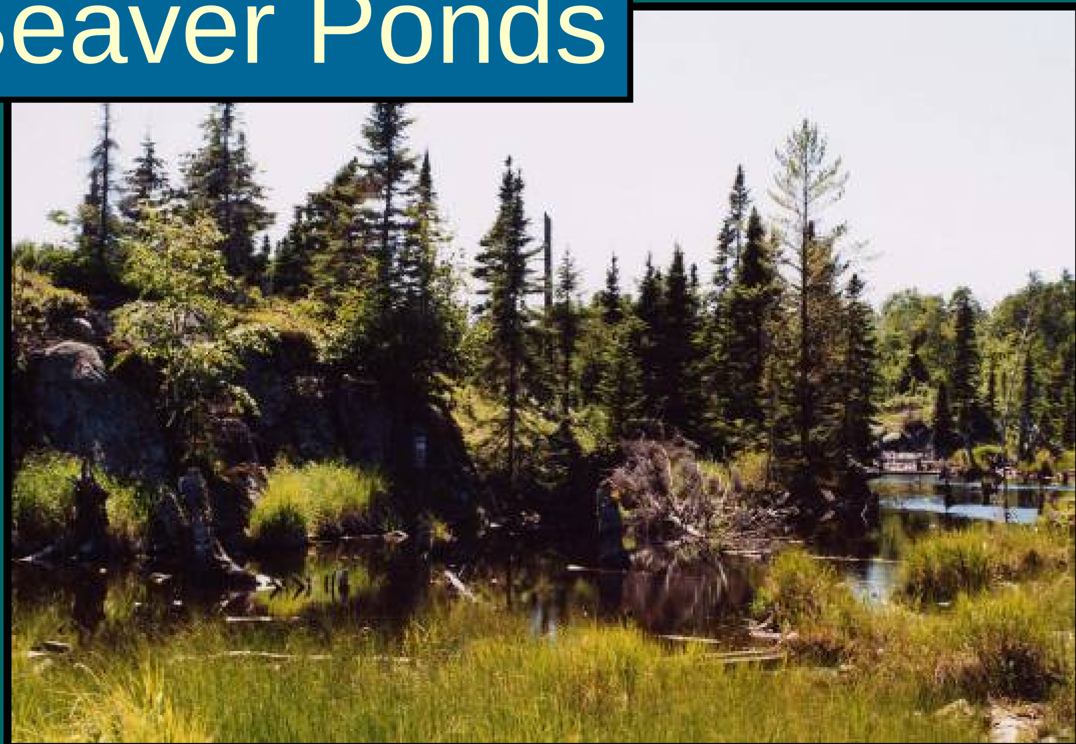
Sedge “wet” meadow

Forested

Scrub (alder)

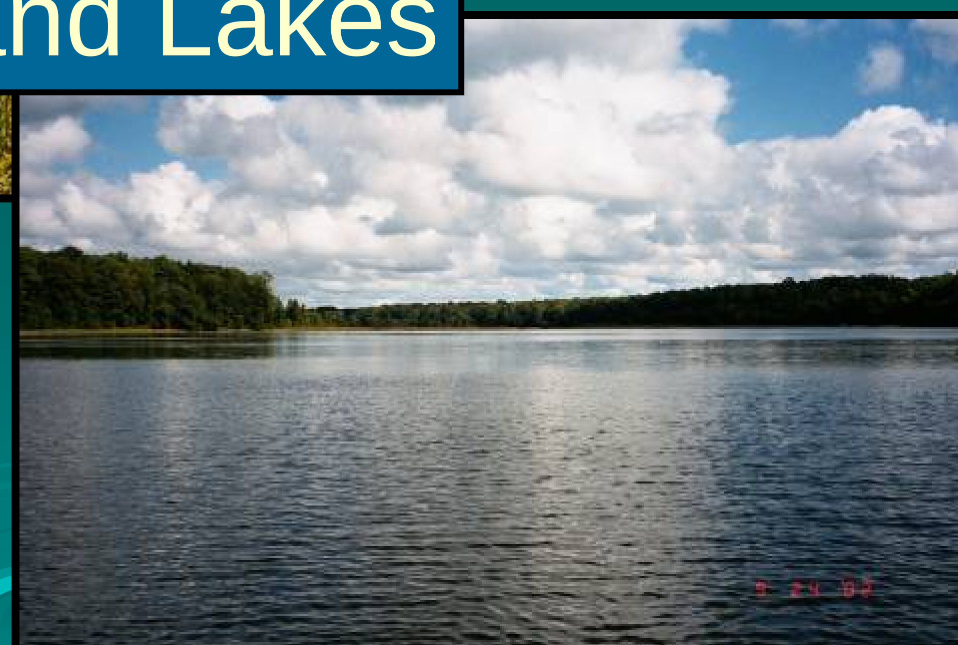
http://dnr.wi.gov/org/water/fhp/wetlands/types.shtml

Beaver Ponds

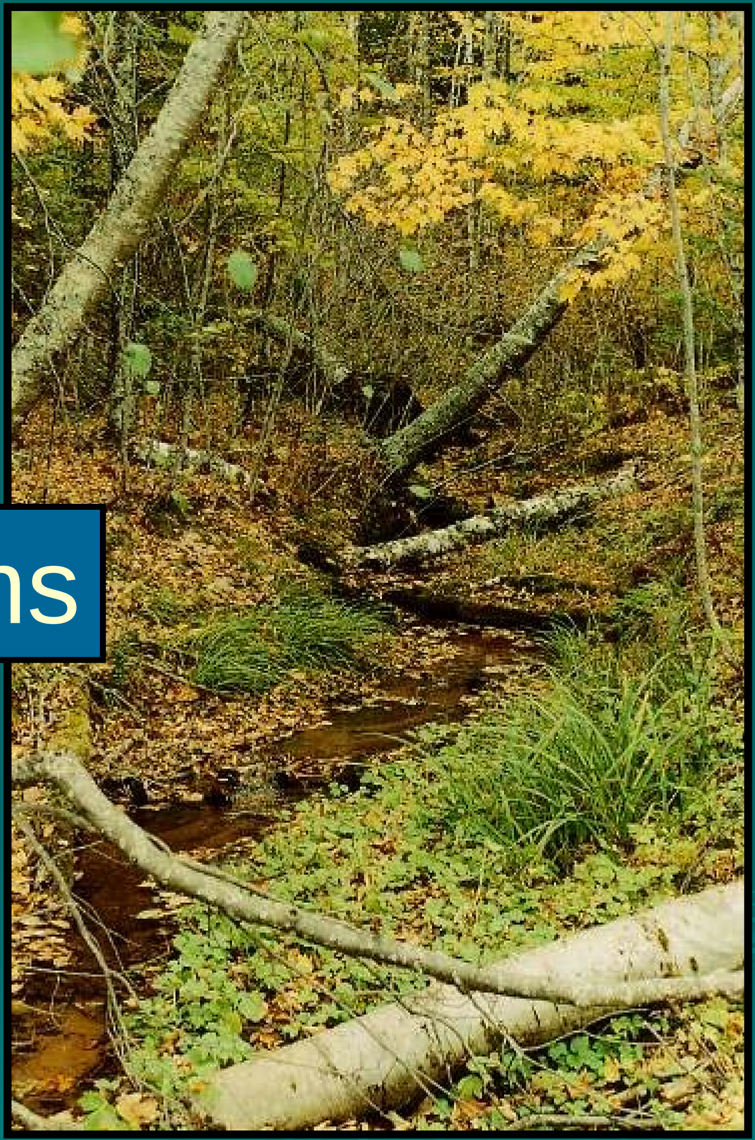


Bogs

Inland Lakes



Streams



Large Rivers


St. Croix


Mississippi

Research in Great Lakes Parks

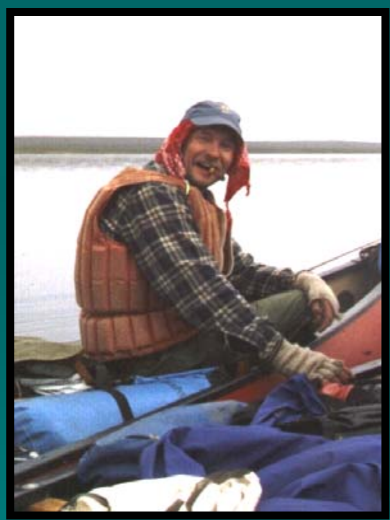
Research in Great Lakes Parks

Research in Great Lakes Parks

Research in Great Lakes Parks

Synthesis Inspiration

- Lots of available research
- Two new aquatic professionals
- Monitoring protocols under development



Bill Route, GLKN

Daren Carlisle, NPS → USGS

Synthesis Objectives

- Identify aquatic research themes
- Offer considerations for future monitoring and research
- Raise the profile of Great Lakes parks

Today's Objectives

- Describe the aquatic synthesis process
- Quickly tour the document
- Summarize the Network-wide synthesis
- Offer helpful hints to future synthesizers

Methods

- Literature search
  - Park files and libraries
  - Midwest Regional Office files
  - Online literature searches
  - USGS reports (NAWQA and Minnesota District)

Methods

- Literature review & organization
  - Grouped by park
  - Grouped into natural categories
- Literature recording
  - Summary Table (author, date, approach, results, conclusions/recommendations)
- Water resource statistics (thanks, Ulf!)
  - Length of streams, rivers, shoreline
  - Area of lakes, wetlands, large rivers

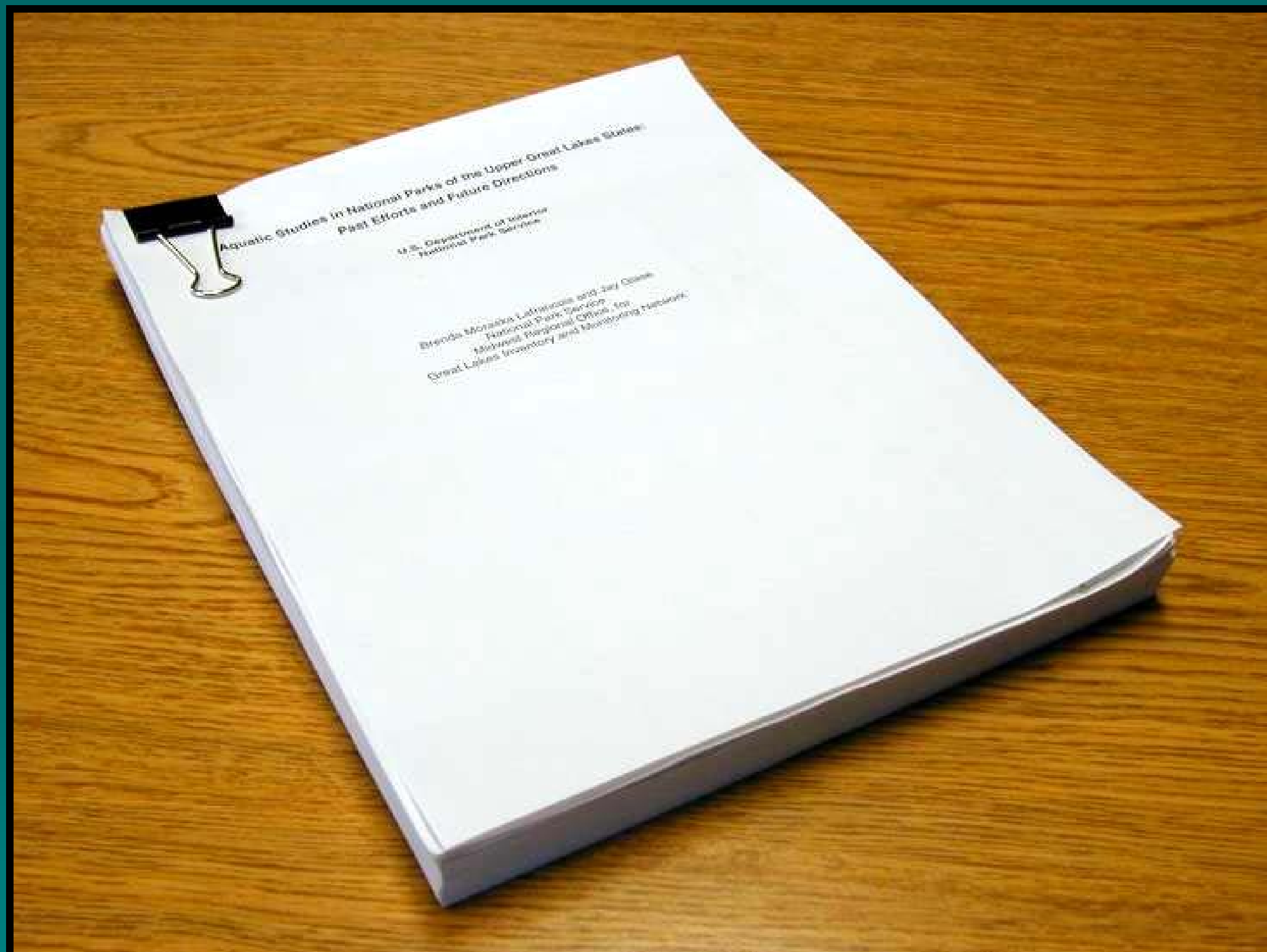
Methods: Analysis

- Two levels of summary and synthesis
  - Park-by-park
    - Maps, water resource stats, research summary, analysis of strengths/gaps, considerations
  - Network-wide
    - Summary of research themes
    - Analysis of strengths/gaps across parks
    - Considerations

Research Categories

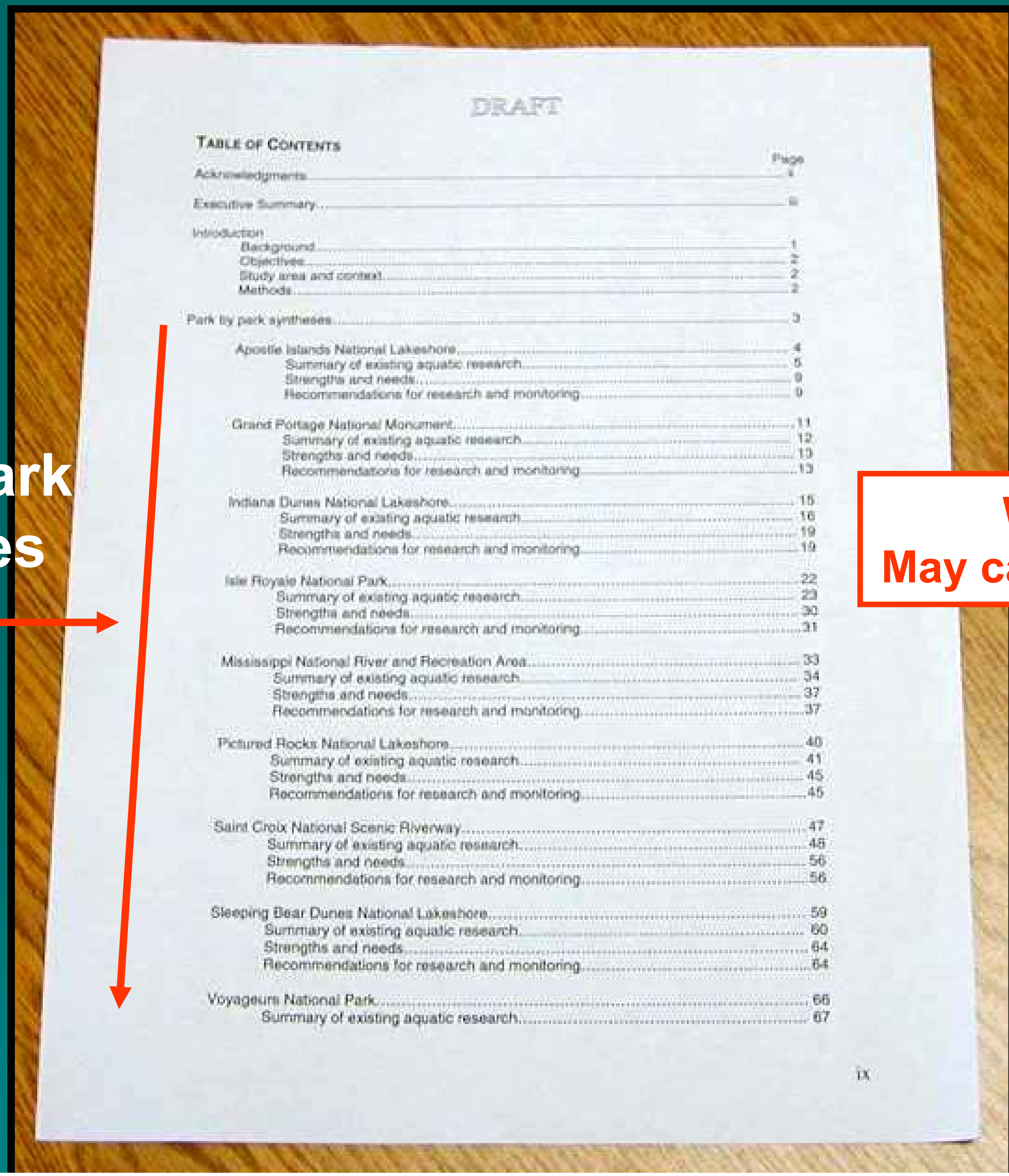
- General resource documents and plans
- Water quality
- Biology and ecology
- Fish
- Aquatic wildlife
- Amphibians and reptiles
- Wetlands and aquatic vegetation
- Contaminants
- Hydrology
- Groundwater
- Physical structure and processes

Synthesis Tour



Tour: Table of Contents

Park-by-Park Syntheses



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May cause dizziness.**

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Network-wide Synthesis

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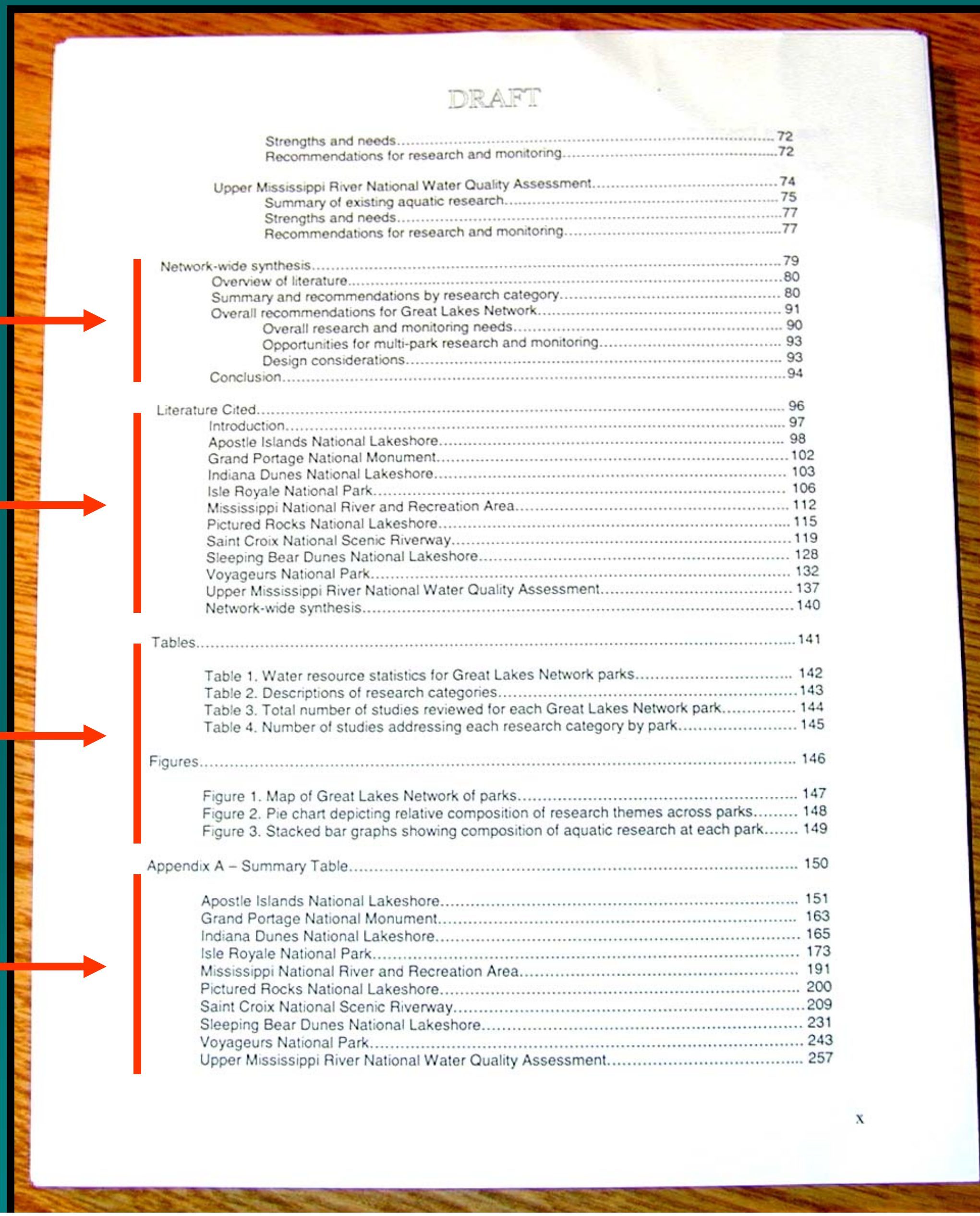
Tables & Figures

Summary Table



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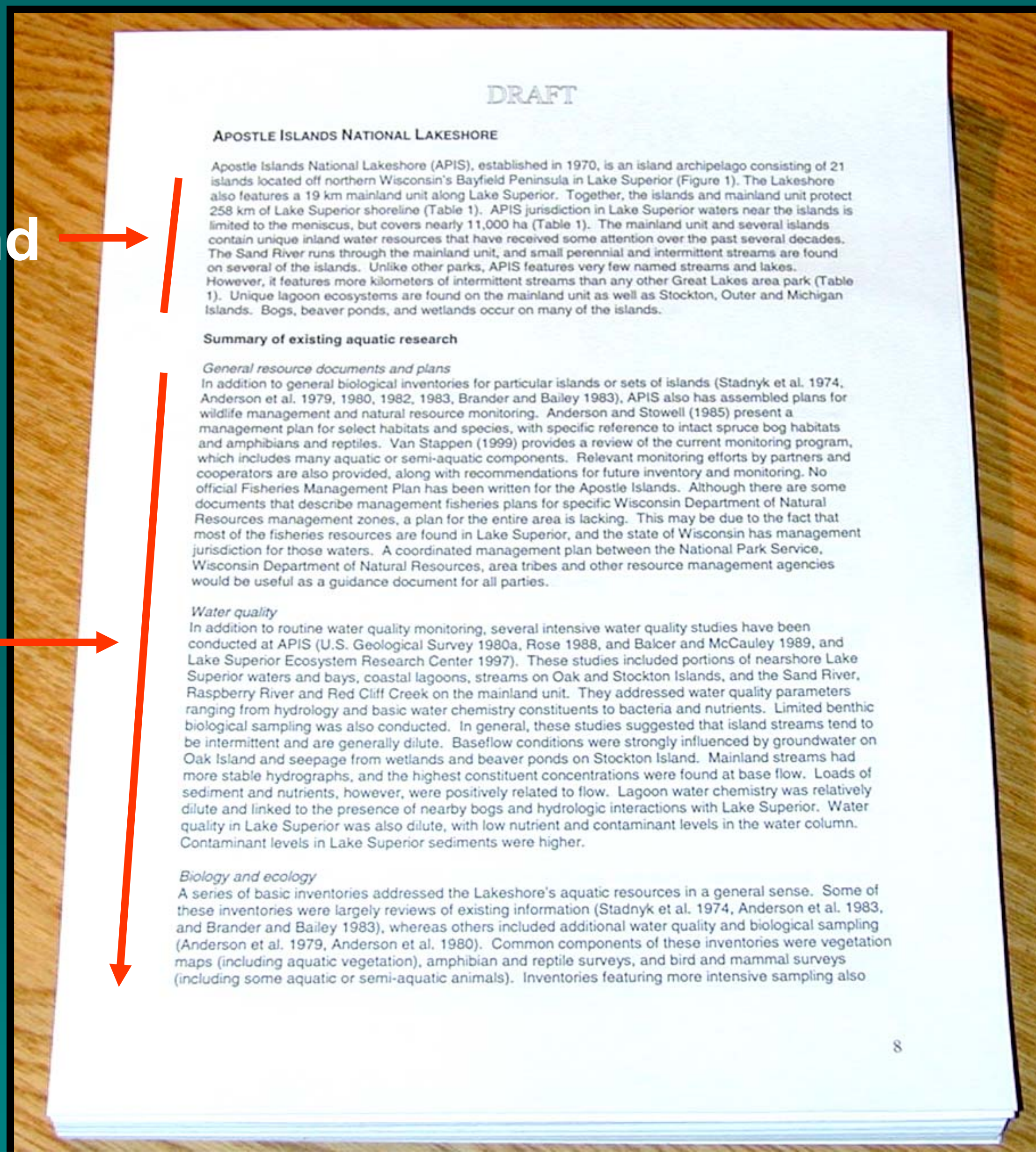
Tour: Park-by-Park Synthesis

Background

Summary



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APOSTLE ISLANDS NATIONAL LAKESHORE

Apostle Islands National Lakeshore (APIS), established in 1970, is an island archipelago consisting of 21 islands located off northern Wisconsin's Bayfield Peninsula in Lake Superior (Figure 1). The Lakeshore also features a 19 km mainland unit along Lake Superior. Together, the islands and mainland unit protect 258 km of Lake Superior shoreline (Table 1). APIS jurisdiction in Lake Superior waters near the islands is limited to the meniscus, but covers nearly 11,000 ha (Table 1). The mainland unit and several islands contain unique inland water resources that have received some attention over the past several decades. The Sand River runs through the mainland unit, and small perennial and intermittent streams are found on several of the islands. Unlike other parks, APIS features very few named streams and lakes. However, it features more kilometers of intermittent streams than any other Great Lakes area park (Table 1). Unique lagoon ecosystems are found on the mainland unit as well as Stockton, Outer and Michigan Islands. Bogs, beaver ponds, and wetlands occur on many of the islands.

Summary of existing aquatic research

General resource documents and plans
In addition to general biological inventories for particular islands or sets of islands (Stadnyk et al. 1974, Anderson et al. 1979, 1980, 1982, 1983, Brander and Bailey 1983), APIS also has assembled plans for wildlife management and natural resource monitoring. Anderson and Stowell (1985) present a management plan for select habitats and species, with specific reference to intact spruce bog habitats and amphibians and reptiles. Van Stappen (1999) provides a review of the current monitoring program, which includes many aquatic or semi-aquatic components. Relevant monitoring efforts by partners and cooperators are also provided, along with recommendations for future inventory and monitoring. No official Fisheries Management Plan has been written for the Apostle Islands. Although there are some documents that describe management fisheries plans for specific Wisconsin Department of Natural Resources management zones, a plan for the entire area is lacking. This may be due to the fact that most of the fisheries resources are found in Lake Superior, and the state of Wisconsin has management jurisdiction for those waters. A coordinated management plan between the National Park Service, Wisconsin Department of Natural Resources, area tribes and other resource management agencies would be useful as a guidance document for all parties.

Water quality
In addition to routine water quality monitoring, several intensive water quality studies have been conducted at APIS (U.S. Geological Survey 1980a, Rose 1988, and Balcer and McCauley 1989, and Lake Superior Ecosystem Research Center 1997). These studies included portions of nearshore Lake Superior waters and bays, coastal lagoons, streams on Oak and Stockton Islands, and the Sand River, Raspberry River and Red Cliff Creek on the mainland unit. They addressed water quality parameters ranging from hydrology and basic water chemistry constituents to bacteria and nutrients. Limited benthic biological sampling was also conducted. In general, these studies suggested that island streams tend to be intermittent and are generally dilute. Baseflow conditions were strongly influenced by groundwater on Oak Island and seepage from wetlands and beaver ponds on Stockton Island. Mainland streams had more stable hydrographs, and the highest constituent concentrations were found at base flow. Loads of sediment and nutrients, however, were positively related to flow. Lagoon water chemistry was relatively dilute and linked to the presence of nearby bogs and hydrologic interactions with Lake Superior. Water quality in Lake Superior was also dilute, with low nutrient and contaminant levels in the water column. Contaminant levels in Lake Superior sediments were higher.

Biology and ecology
A series of basic inventories addressed the Lakeshore's aquatic resources in a general sense. Some of these inventories were largely reviews of existing information (Stadnyk et al. 1974, Anderson et al. 1983, and Brander and Bailey 1983), whereas others included additional water quality and biological sampling (Anderson et al. 1979, Anderson et al. 1980). Common components of these inventories were vegetation maps (including aquatic vegetation), amphibian and reptile surveys, and bird and mammal surveys (including some aquatic or semi-aquatic animals). Inventories featuring more intensive sampling also

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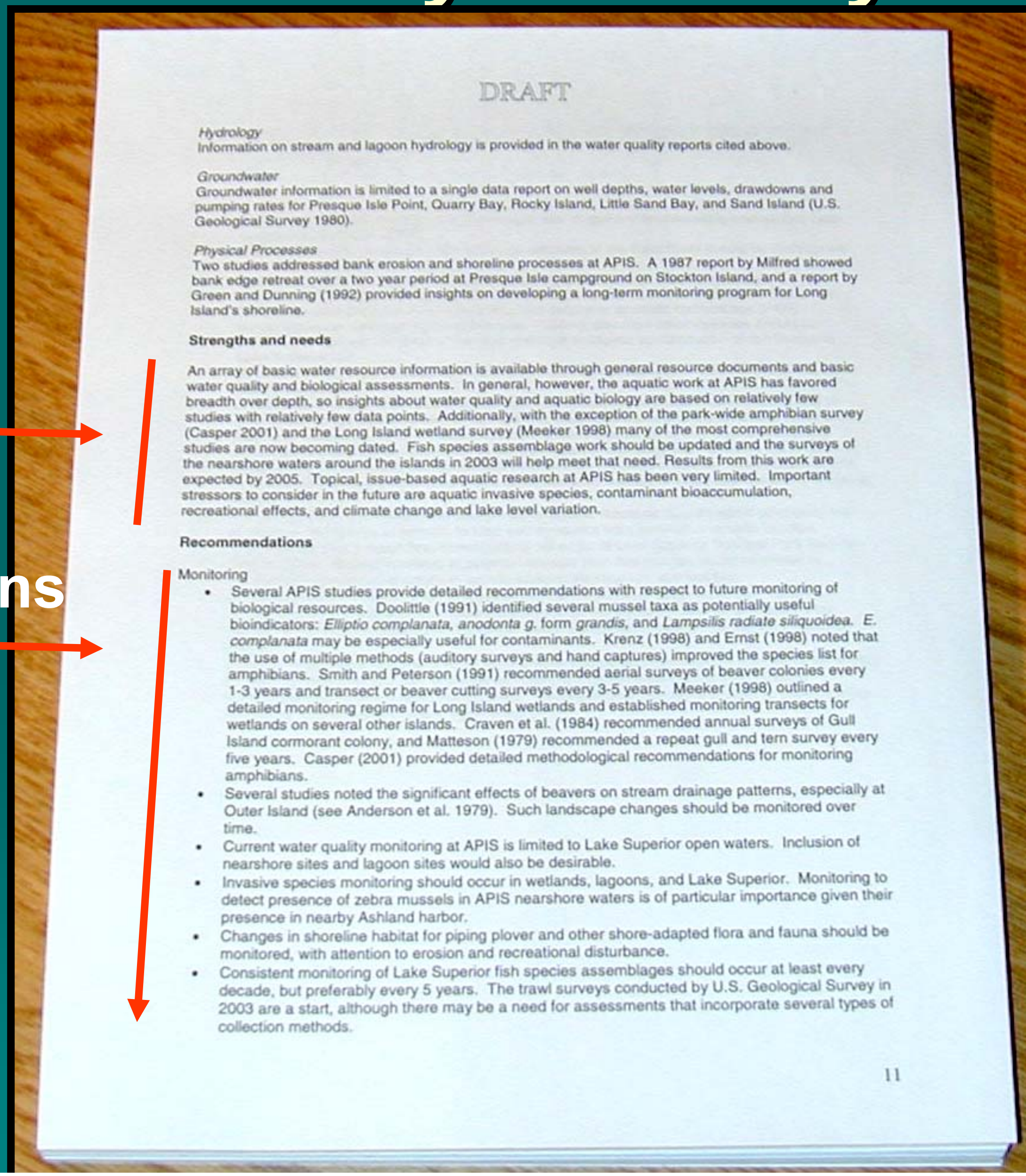
Tour: Park-by-Park Synthesis

Strengths & Gaps

Considerations



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Hydrology
Information on stream and lagoon hydrology is provided in the water quality reports cited above.

Groundwater
Groundwater information is limited to a single data report on well depths, water levels, drawdowns and pumping rates for Presque Isle Point, Quarry Bay, Rocky Island, Little Sand Bay, and Sand Island (U.S. Geological Survey 1980).

Physical Processes
Two studies addressed bank erosion and shoreline processes at APIS. A 1987 report by Milfred showed bank edge retreat over a two year period at Presque Isle campground on Stockton Island, and a report by Green and Dunning (1992) provided insights on developing a long-term monitoring program for Long Island's shoreline.

Strengths and needs

An array of basic water resource information is available through general resource documents and basic water quality and biological assessments. In general, however, the aquatic work at APIS has favored breadth over depth, so insights about water quality and aquatic biology are based on relatively few studies with relatively few data points. Additionally, with the exception of the park-wide amphibian survey (Casper 2001) and the Long Island wetland survey (Meeker 1998) many of the most comprehensive studies are now becoming dated. Fish species assemblage work should be updated and the surveys of the nearshore waters around the islands in 2003 will help meet that need. Results from this work are expected by 2005. Topical, issue-based aquatic research at APIS has been very limited. Important stressors to consider in the future are aquatic invasive species, contaminant bioaccumulation, recreational effects, and climate change and lake level variation.

Recommendations

Monitoring

- Several APIS studies provide detailed recommendations with respect to future monitoring of biological resources. Doolittle (1991) identified several mussel taxa as potentially useful bioindicators: *Elliptio complanata, anodonta g.* form *grandis*, and *Lampsilis radiate siliquoidea*. *E. complanata* may be especially useful for contaminants. Krenz (1998) and Ernst (1998) noted that the use of multiple methods (auditory surveys and hand captures) improved the species list for amphibians. Smith and Peterson (1991) recommended aerial surveys of beaver colonies every 1-3 years and transect or beaver cutting surveys every 3-5 years. Meeker (1998) outlined a detailed monitoring regime for Long Island wetlands and established monitoring transects for wetlands on several other islands. Craven et al. (1984) recommended annual surveys of Gull Island cormorant colony, and Matteson (1979) recommended a repeat gull and tern survey every five years. Casper (2001) provided detailed methodological recommendations for monitoring amphibians.
- Several studies noted the significant effects of beavers on stream drainage patterns, especially at Outer Island (see Anderson et al. 1979). Such landscape changes should be monitored over time.
- Current water quality monitoring at APIS is limited to Lake Superior open waters. Inclusion of nearshore sites and lagoon sites would also be desirable.
- Invasive species monitoring should occur in wetlands, lagoons, and Lake Superior. Monitoring to detect presence of zebra mussels in APIS nearshore waters is of particular importance given their presence in nearby Ashland harbor.
- Changes in shoreline habitat for piping plover and other shore-adapted flora and fauna should be monitored, with attention to erosion and recreational disturbance.
- Consistent monitoring of Lake Superior fish species assemblages should occur at least every decade, but preferably every 5 years. The trawl surveys conducted by U.S. Geological Survey in 2003 are a start, although there may be a need for assessments that incorporate several types of collection methods.

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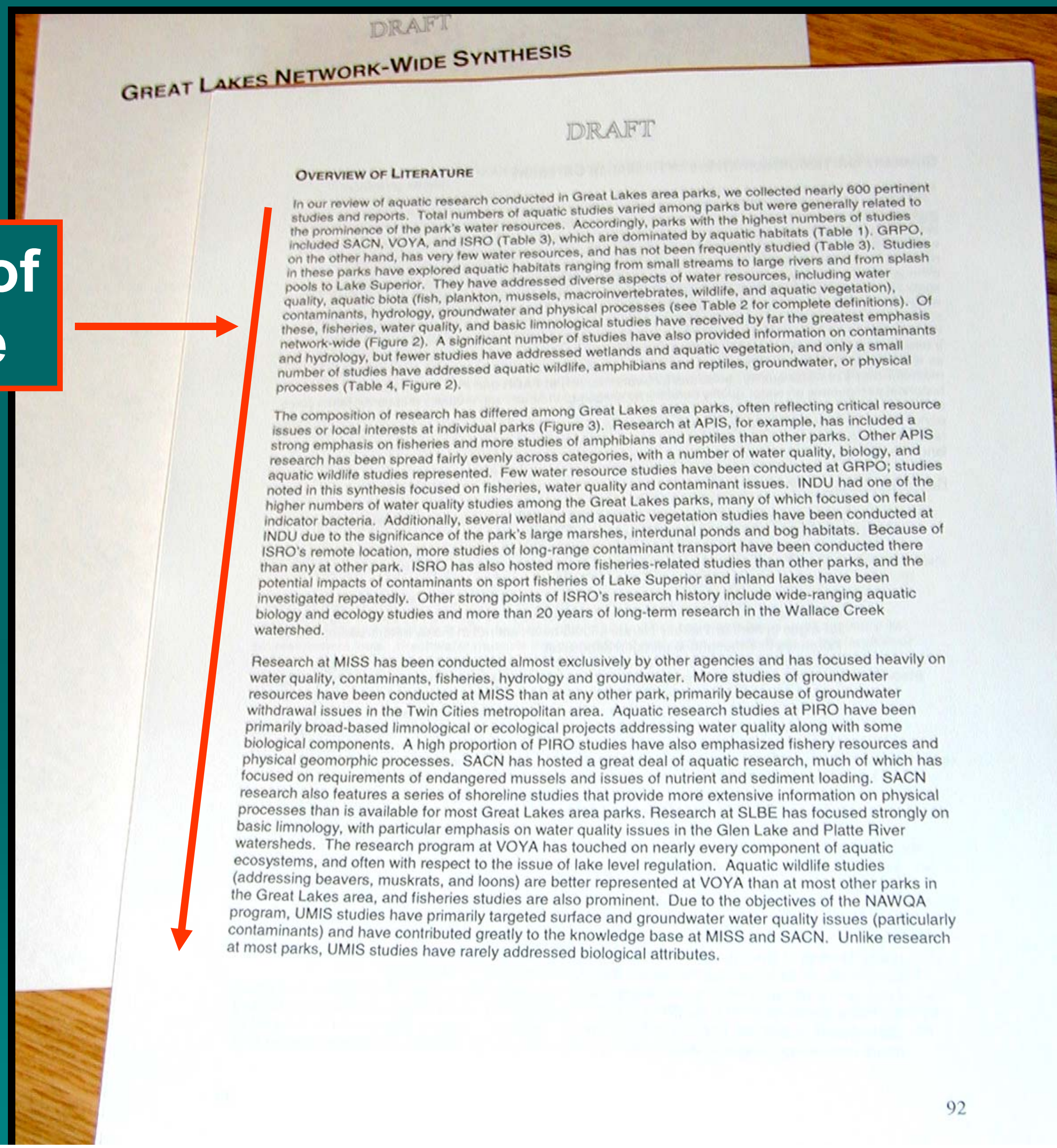
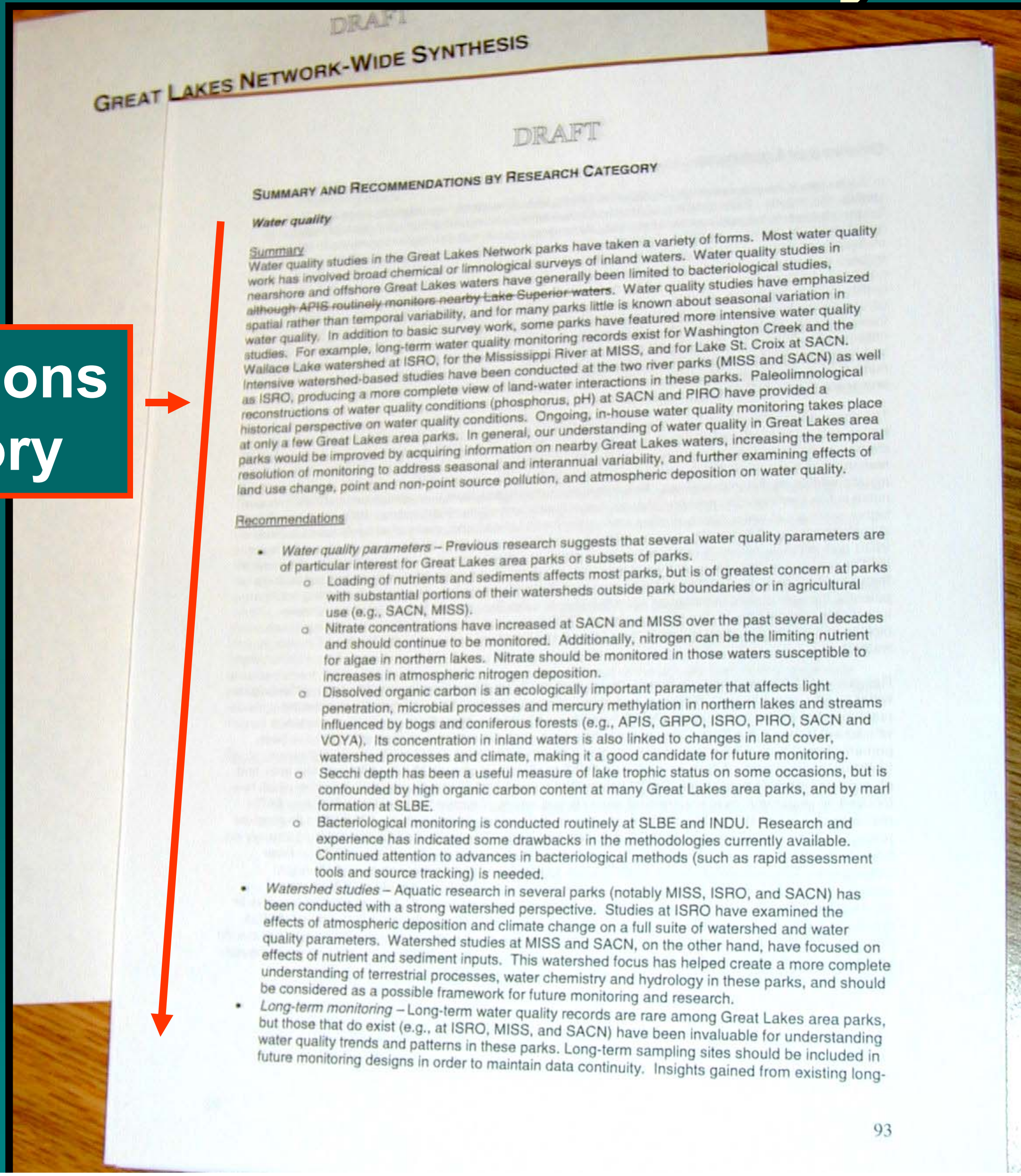
Tour: Network-wide Synthesis

Overview of Literature



Tour: Network-wide Synthesis

Considerations by Category



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GREAT LAKES NETWORK-WIDE SYNTHESIS

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SUMMARY AND RECOMMENDATIONS BY RESEARCH CATEGORY

Water quality

Summary

Water quality studies in the Great Lakes Network parks have taken a variety of forms. Most water quality work has involved broad chemical or limnological surveys of inland waters. Water quality studies in nearshore and offshore Great Lakes waters have generally been limited to bacteriological studies, ~~although APIS routinely monitors nearby Lake Superior waters~~. Water quality studies have emphasized spatial rather than temporal variability, and for many parks little is known about seasonal variation in water quality. In addition to basic survey work, some parks have featured more intensive water quality studies. For example, long-term water quality monitoring records exist for Washington Creek and the Wallace Lake watershed at ISRO, for the Mississippi River at MISS, and for Lake St. Croix at SACN. Intensive watershed-based studies have been conducted at the two river parks (MISS and SACN) as well as ISRO, producing a more complete view of land-water interactions in these parks. Paleolimnological reconstructions of water quality conditions (phosphorus, pH) at SACN and PIRO have provided a historical perspective on water quality conditions. Ongoing, in-house water quality monitoring takes place at only a few Great Lakes area parks. In general, our understanding of water quality in Great Lakes area parks would be improved by acquiring information on nearby Great Lakes waters, increasing the temporal resolution of monitoring to address seasonal and interannual variability, and further examining effects of land use change, point and non-point source pollution, and atmospheric deposition on water quality.

Recommendations

- *Water quality parameters* – Previous research suggests that several water quality parameters are of particular interest for Great Lakes area parks or subsets of parks.
  - Loading of nutrients and sediments affects most parks, but is of greatest concern at parks with substantial portions of their watersheds outside park boundaries or in agricultural use (e.g., SACN, MISS).
  - Nitrate concentrations have increased at SACN and MISS over the past several decades and should continue to be monitored. Additionally, nitrogen can be the limiting nutrient for algae in northern lakes. Nitrate should be monitored in those waters susceptible to increases in atmospheric nitrogen deposition.
  - Dissolved organic carbon is an ecologically important parameter that affects light penetration, microbial processes and mercury methylation in northern lakes and streams influenced by bogs and coniferous forests (e.g., APIS, GRPO, ISRO, PIRO, SACN and VOYA). Its concentration in inland waters is also linked to changes in land cover, watershed processes and climate, making it a good candidate for future monitoring.
  - Secchi depth has been a useful measure of lake trophic status on some occasions, but is confounded by high organic carbon content at many Great Lakes area parks, and by marl formation at SLBE.
  - Bacteriological monitoring is conducted routinely at SLBE and INDU. Research and experience has indicated some drawbacks in the methodologies currently available. Continued attention to advances in bacteriological methods (such as rapid assessment tools and source tracking) is needed.
- *Watershed studies* – Aquatic research in several parks (notably MISS, ISRO, and SACN) has been conducted with a strong watershed perspective. Studies at ISRO have examined the effects of atmospheric deposition and climate change on a full suite of watershed and water quality parameters. Watershed studies at MISS and SACN, on the other hand, have focused on effects of nutrient and sediment inputs. This watershed focus has helped create a more complete understanding of terrestrial processes, water chemistry and hydrology in these parks, and should be considered as a possible framework for future monitoring and research.
- *Long-term monitoring* – Long-term water quality records are rare among Great Lakes area parks, but those that do exist (e.g., at ISRO, MISS, and SACN) have been invaluable for understanding water quality trends and patterns in these parks. Long-term sampling sites should be included in future monitoring designs in order to maintain data continuity. Insights gained from existing long-

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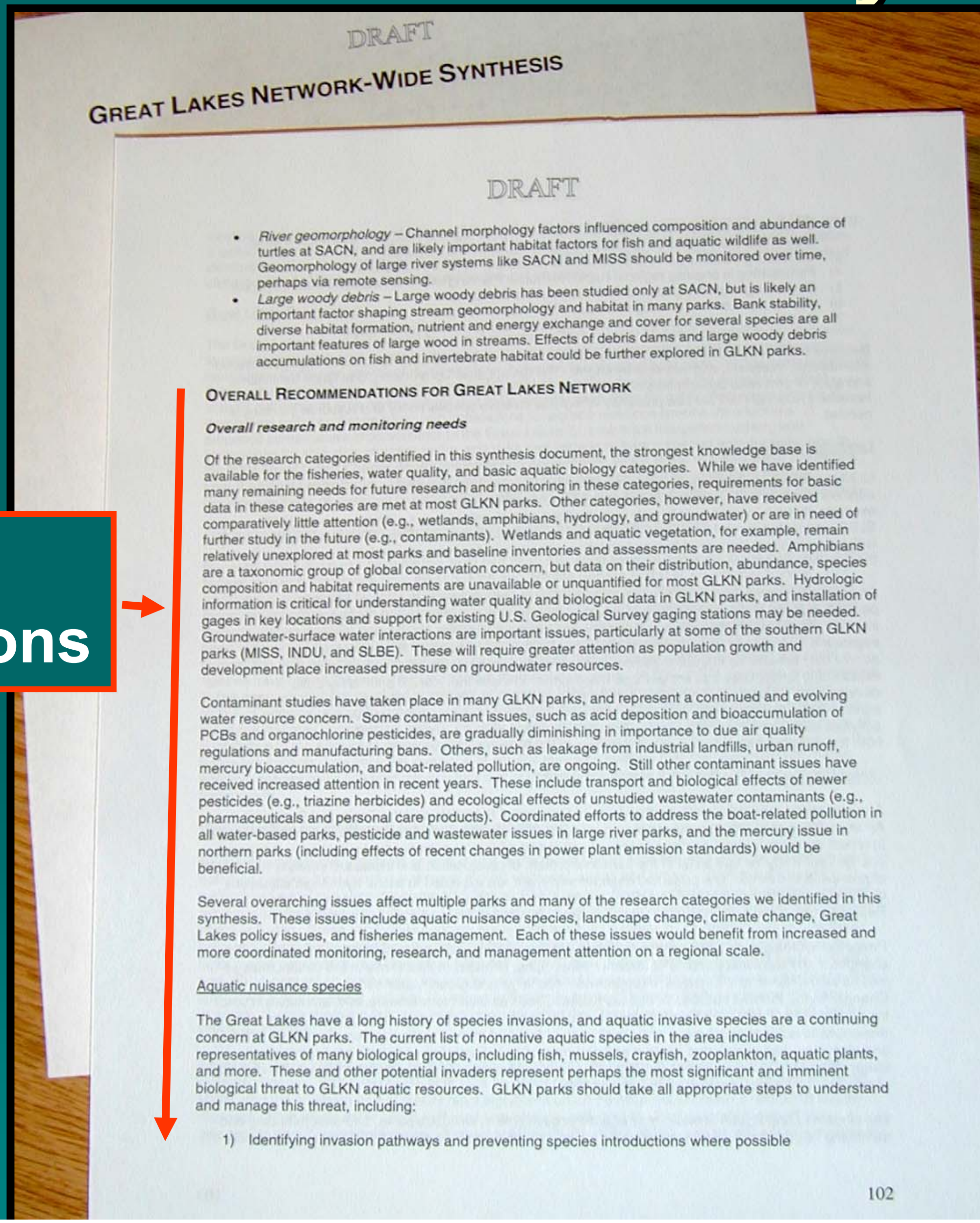
Tour: Network-wide Synthesis



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GREAT LAKES NETWORK-WIDE SYNTHESIS

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- *River geomorphology* – Channel morphology factors influenced composition and abundance of turtles at SACN, and are likely important habitat factors for fish and aquatic wildlife as well. Geomorphology of large river systems like SACN and MISS should be monitored over time, perhaps via remote sensing.
- *Large woody debris* – Large woody debris has been studied only at SACN, but is likely an important factor shaping stream geomorphology and habitat in many parks. Bank stability, diverse habitat formation, nutrient and energy exchange and cover for several species are all important features of large wood in streams. Effects of debris dams and large woody debris accumulations on fish and invertebrate habitat could be further explored in GLKN parks.

OVERALL RECOMMENDATIONS FOR GREAT LAKES NETWORK

Overall research and monitoring needs

Of the research categories identified in this synthesis document, the strongest knowledge base is available for the fisheries, water quality, and basic aquatic biology categories. While we have identified many remaining needs for future research and monitoring in these categories, requirements for basic data in these categories are met at most GLKN parks. Other categories, however, have received comparatively little attention (e.g., wetlands, amphibians, hydrology, and groundwater) or are in need of further study in the future (e.g., contaminants). Wetlands and aquatic vegetation, for example, remain relatively unexplored at most parks and baseline inventories and assessments are needed. Amphibians are a taxonomic group of global conservation concern, but data on their distribution, abundance, species composition and habitat requirements are unavailable or unquantified for most GLKN parks. Hydrologic information is critical for understanding water quality and biological data in GLKN parks, and installation of gages in key locations and support for existing U.S. Geological Survey gaging stations may be needed. Groundwater-surface water interactions are important issues, particularly at some of the southern GLKN parks (MISS, INDU, and SLBE). These will require greater attention as population growth and development place increased pressure on groundwater resources.

Contaminant studies have taken place in many GLKN parks, and represent a continued and evolving water resource concern. Some contaminant issues, such as acid deposition and bioaccumulation of PCBs and organochlorine pesticides, are gradually diminishing in importance to due air quality regulations and manufacturing bans. Others, such as leakage from industrial landfills, urban runoff, mercury bioaccumulation, and boat-related pollution, are ongoing. Still other contaminant issues have received increased attention in recent years. These include transport and biological effects of newer pesticides (e.g., triazine herbicides) and ecological effects of unstudied wastewater contaminants (e.g., pharmaceuticals and personal care products). Coordinated efforts to address the boat-related pollution in all water-based parks, pesticide and wastewater issues in large river parks, and the mercury issue in northern parks (including effects of recent changes in power plant emission standards) would be beneficial.

Several overarching issues affect multiple parks and many of the research categories we identified in this synthesis. These issues include aquatic nuisance species, landscape change, climate change, Great Lakes policy issues, and fisheries management. Each of these issues would benefit from increased and more coordinated monitoring, research, and management attention on a regional scale.

Aquatic nuisance species

The Great Lakes have a long history of species invasions, and aquatic invasive species are a continuing concern at GLKN parks. The current list of nonnative aquatic species in the area includes representatives of many biological groups, including fish, mussels, crayfish, zooplankton, aquatic plants, and more. These and other potential invaders represent perhaps the most significant and imminent biological threat to GLKN aquatic resources. GLKN parks should take all appropriate steps to understand and manage this threat, including:

1) Identifying invasion pathways and preventing species introductions where possible

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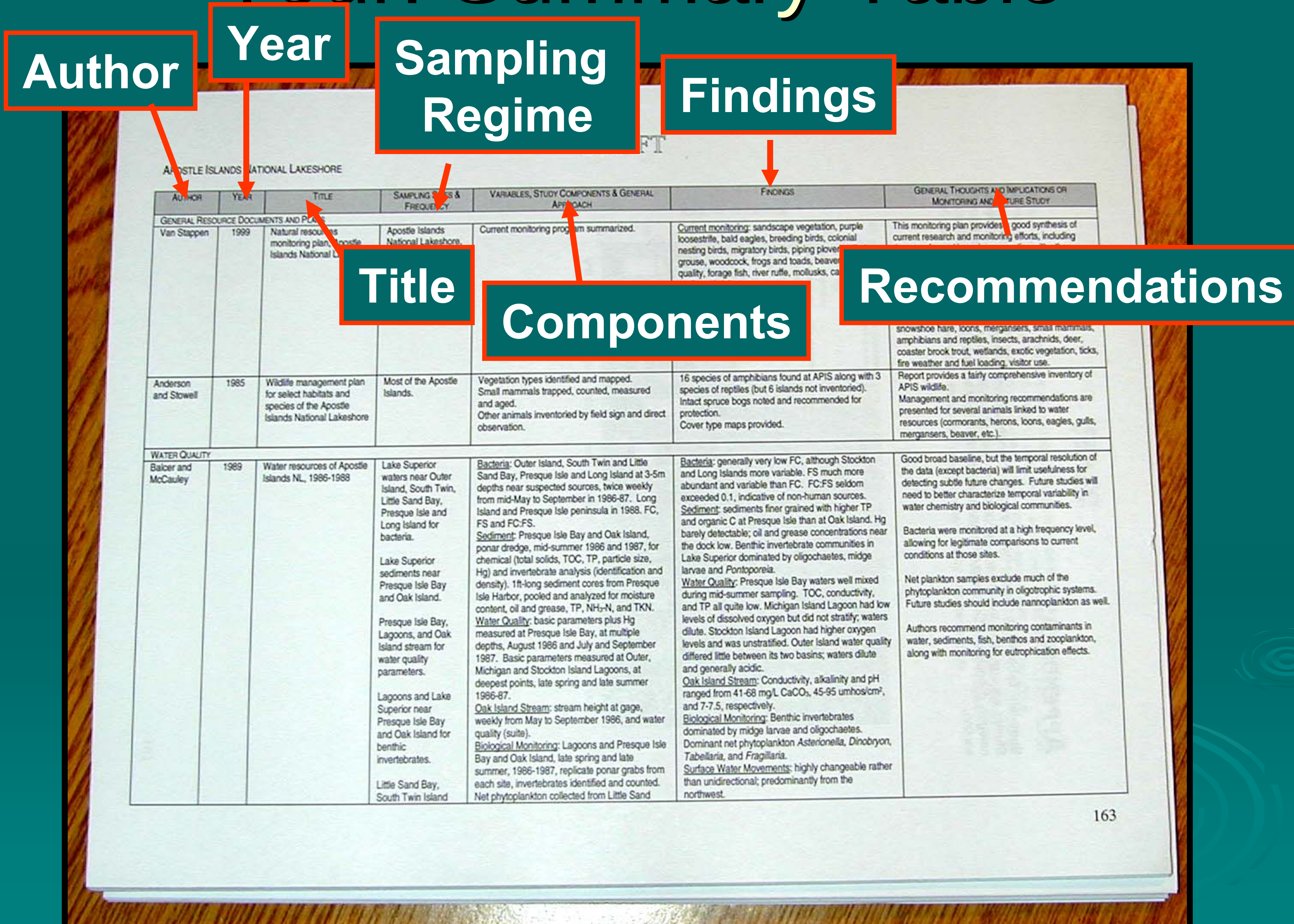
Overall Considerations

Tour: Summary Table

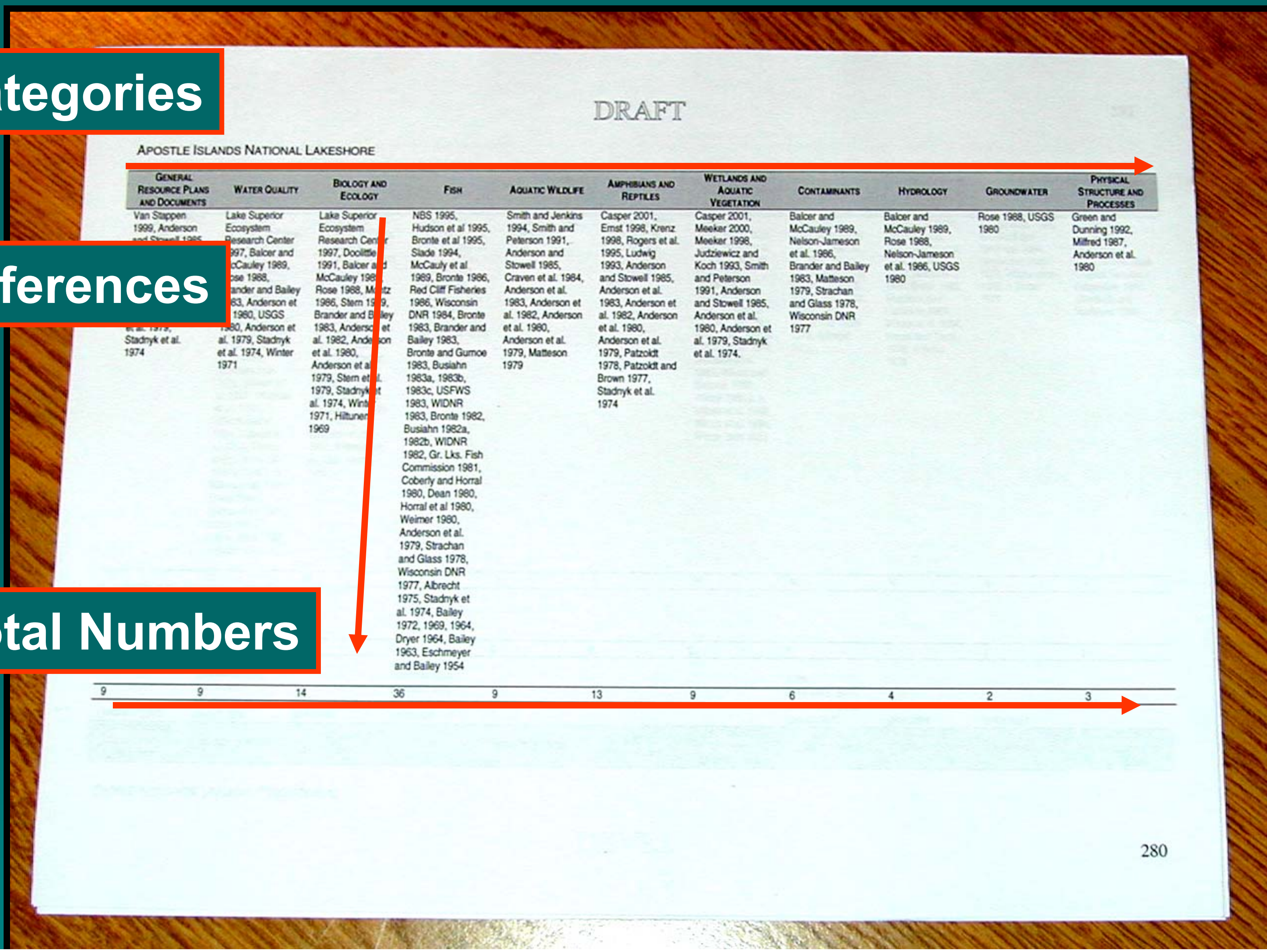


Tour: Super Summary Table

Categories

References

Total Numbers



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APOSTLE ISLANDS NATIONAL LAKESHORE

General Resource Plans and Documents	Water Quality	Biology and Ecology	Fish	Aquatic Wildlife	Amphibians and Reptiles	Wetlands and Aquatic Vegetation	Contaminants	Hydrology	Groundwater	Physical Structure and Processes
Van Stappen 1999, Anderson [illegible] Stadnyk et al. 1974	Lake Superior Ecosystem Research Center [illegible]997, Balcer and [illegible]cCauley 1989, [illegible]se 1988, [illegible]ander and Bailey [illegible]83, Anderson et [illegible] 1980, USGS [illegible]80, Anderson et al. 1979, Stadnyk et al. 1974, Winter 1971	Lake Superior Ecosystem Research Cen[illegible] 1997, Doolittle 1991, Balcer a[illegible] McCauley 198[illegible], Rose 1988, M[illegible]tz 1986, Stern 19[illegible]9, Brander and B[illegible]ley 1983, Anders[illegible] et al. 1982, Ande[illegible]on et al. 1980, Anderson et a[illegible] 1979, Stern et [illegible]. 1979, Stadnyk [illegible]t al. 1974, Wint[illegible] 1971, Hiltunen 1969	NBS 1995, Hudson et al 1995, Bronte et al 1995, Slade 1994, McCauly et al 1989, Bronte 1986, Red Cliff Fisheries 1986, Wisconsin DNR 1984, Bronte 1983, Brander and Bailey 1983, Bronte and Gumoe 1983, Busiahn 1983a, 1983b, 1983c, USFWS 1983, WIDNR 1983, Bronte 1982, Busiahn 1982a, 1982b, WIDNR 1982, Gr. Lks. Fish Commission 1981, Coberly and Horral 1980, Dean 1980, Horral et al 1980, Weimer 1980, Anderson et al. 1979, Strachan and Glass 1978, Wisconsin DNR 1977, Albrecht 1975, Stadnyk et al. 1974, Bailey 1972, 1969, 1964, Dryer 1964, Bailey 1963, Eschmeyer and Bailey 1954	Smith and Jenkins 1994, Smith and Peterson 1991, Anderson and Stowell 1985, Craven et al. 1984, Anderson et al. 1983, Anderson et al. 1982, Anderson et al. 1980, Anderson et al. 1979, Matteson 1979	Casper 2001, Ernst 1998, Krenz 1998, Rogers et al. 1995, Ludwig 1993, Anderson and Stowell 1985, Anderson et al. 1983, Anderson et al. 1982, Anderson et al. 1980, Anderson et al. 1979, Patzoldt 1978, Patzoldt and Brown 1977, Stadnyk et al. 1974	Casper 2001, Meeker 2000, Meeker 1998, Judziewicz and Koch 1993, Smith and Peterson 1991, Anderson and Stowell 1985, Anderson et al. 1980, Anderson et al. 1979, Stadnyk et al. 1974.	Balcer and McCauley 1989, Nelson-Jameson et al. 1986, Brander and Bailey 1983, Matteson 1979, Strachan and Glass 1978, Wisconsin DNR 1977	Balcer and McCauley 1989, Rose 1988, Nelson-Jameson et al. 1986, USGS 1980	Rose 1988, USGS 1980	Green and Dunning 1992, Milfred 1987, Anderson et al. 1980
9	9	14	36	9	13	9	6	4	2	3

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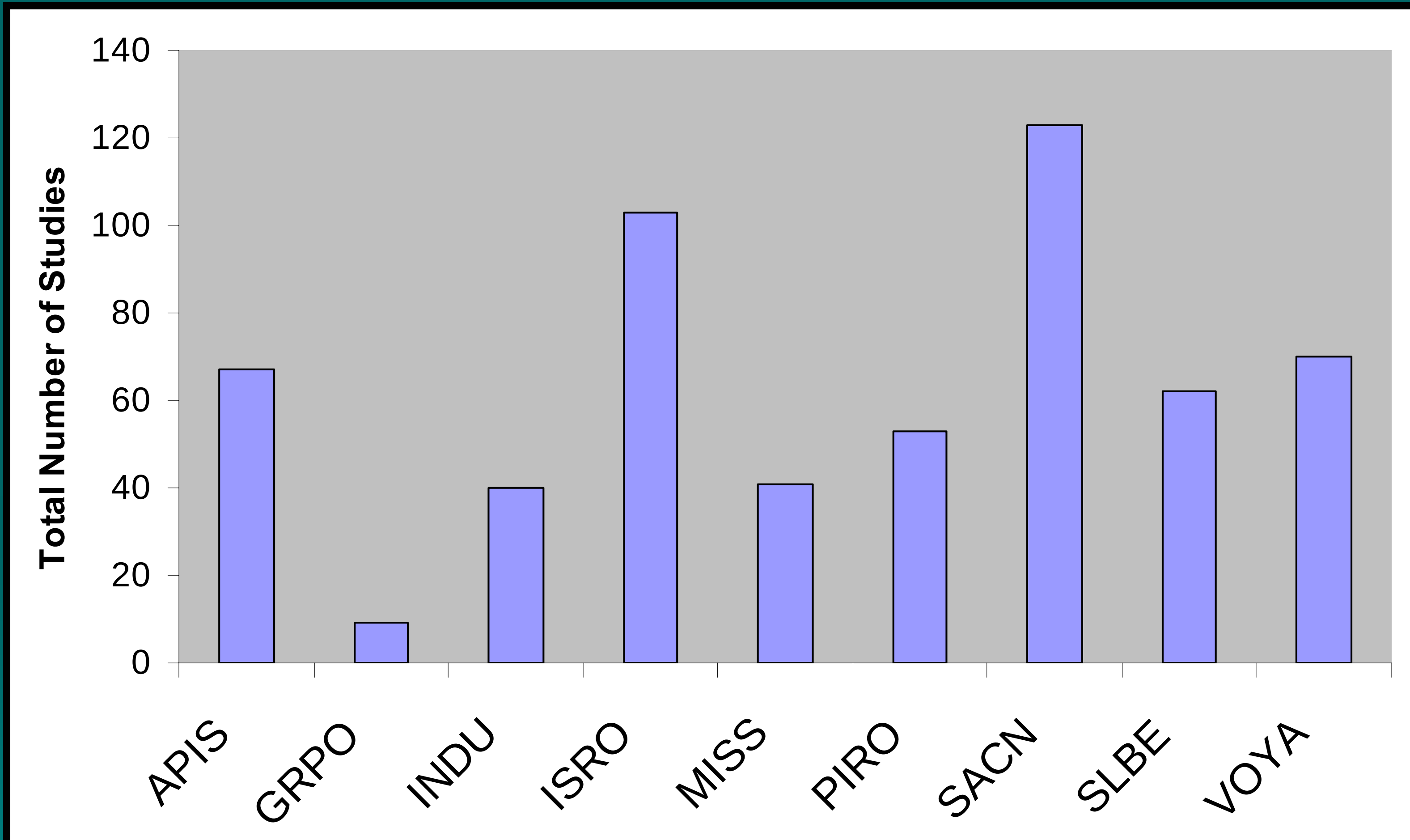
Results: Water Resources

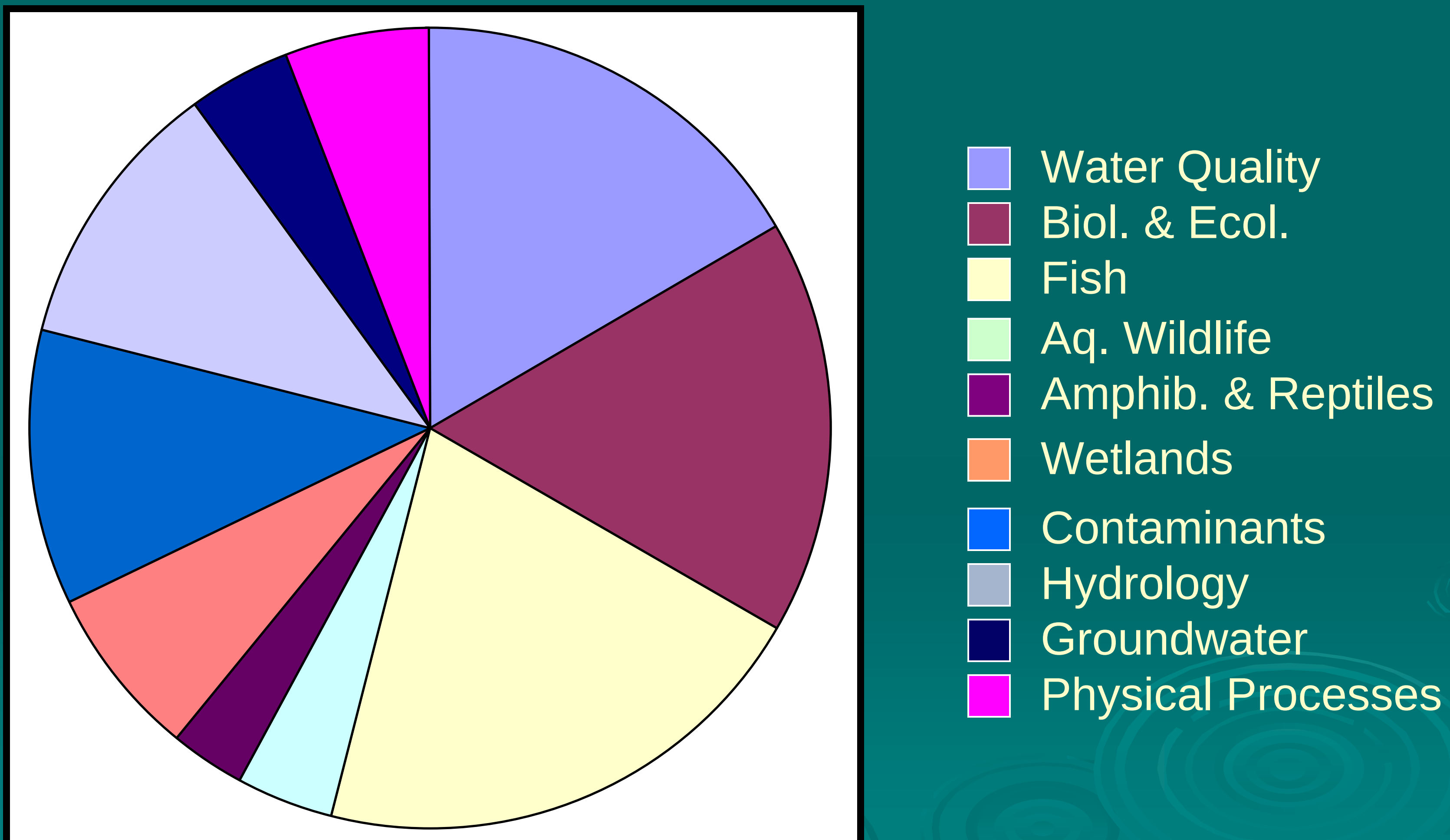
			Park									
	Feature	**Unit**	**APIS**	**GRPO**	**INDU**	**ISRO**	**MISS**	**PIRO**	**SACN**	**SLBE**	**VOYA**	**Total**
Great Lakes	Coastline Length	miles	160	1	12	338	0	38	0	65	0	613
	Great Lakes Area	acres	26,932	0	596	408,173	0	6,025	0	10,501	0	452,226
Streams	Named Streams	number	2	1	4	8	10	19	54	4	10	112
	Intermittent Streams Length	miles	38	0	3	28	22	12	33	0	3	140
	Perennial Streams Length	miles	12	2	8	145	101	71	322	10	119	790
	Mississippi River Length	miles					77					77
	St. Croix River Length	miles							154			154
	Namekagon River Length	miles							107			107
	Ditches Length	miles			12							12
Inland Lakes	Named Lakes	number	0	0	2	42	13	16	13	18	29	133
	Named Lakes Area	acres	0	0	205	8,488	8,927	1,843	8,816	765	71,882	100,926
	Un-named Lakes Area	acres	149	2	n/a	17,825	833	134	470	310	2,630	22,352
	Total Lakes Shoreline	miles	19	0	21	945	194	50	165	25	931	2,351
Wetlands	Total Wetland Area	acres	2,350	0	1,247	17,372	25,990	4,461		1,381	30,930	83,730

Results: Number of Studies



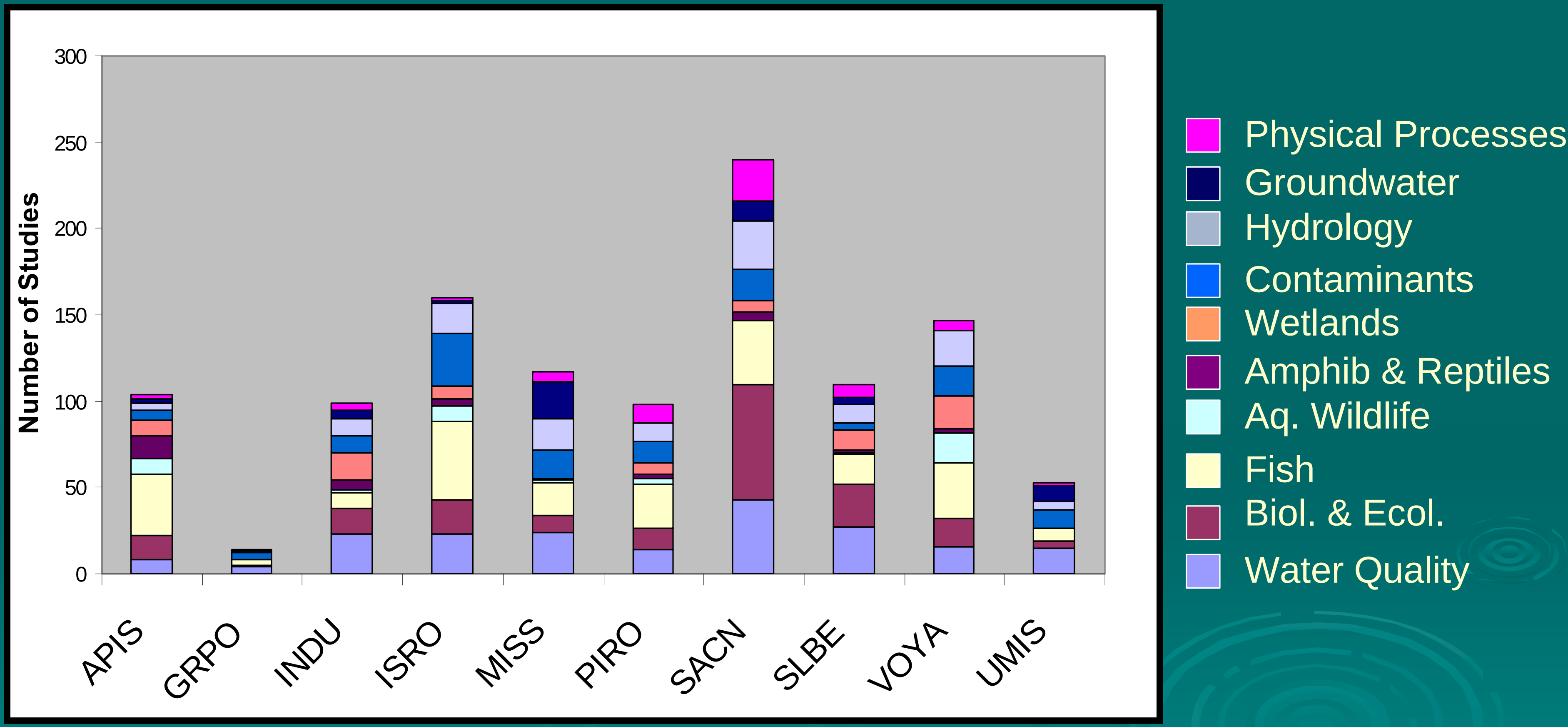
Results: Research Composition

Network-Wide



Results: Research Composition

By Park



Network-wide Findings

- Nearly 600 studies reviewed
- Number of studies varied among parks
- Composition of studies varied among parks

Network-wide Findings

- Overall needs across Network
  - Aquatic nuisance species
  - Landscape change
  - Climate change
  - Fish management
  - Great Lakes and Upper Mississippi River Basin policy issues

Conclusions

- Wealth of water resources in Great Lakes Network parks
- Diverse aquatic research
- Significant water resource issues and threats
- Pressing aquatic research and monitoring needs

Why Synthesize?

- Provides a common reference document
- Generates considerations for future research and monitoring
- Helps in park planning processes
- Helps communicate park needs to partners

Our advice…

- Set aside a lot of time
- Avoid procrastination; easier to synthesize in large blocks
- Be cautious with the gray literature, but alert for hidden gems
- Keep in close contact with parks, Network, and WRD

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